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PREFACE

THIS work is intended mainly for the perusal of employers of labour, foremen, and intelligent workmen. It is hoped it may also be useful to sanitary inspectors, and even on occasion perhaps to medical men. It deals with the risks and dangers (the essential risks and dangers only, those incidental to the occupations) of most of the important industries of this country, their mode of onset, a few of the chief symptoms which may give the workman a note of warning, and the measures which may be taken both by employers and employed to prevent them. The language throughout is strictly simple, and only terms which can be readily understood by any fairly educated individual have been made use of. No scientific classification has been attempted, the various trades being arranged in the form which appears to me most likely to be of practical use. Many of them are referred to under two or more headings, cross references are made when necessary, and thus needless repetition saved.

I must here record my thanks to my brother, Mr. E. J. Parry, B.Sc., F.I.C., for hints on several points of chemistry.

L. A. PARRY.

HOVE, SUSSEX, 1900.

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RISKS AND DANGERS OF VARIOUS OCCUPATIONS AND THEIR PREVENTION.

CHAPTER I.

OCCUPATIONS WHICH ARE ACCOMPANIED BY THE GENERATION AND SCATTERING OF ABNORMAL QUANTITIES OF DUST.

Dusty Occupations in General—Coal Miners—Sweeps, Coalheavers, and Trimmers—Lead, Copper, and Tin Miners—Quarrymen—Masons, Builders, and Bricklayers—Sheffield Trades—Electroplaters—Mother-of-Pearl Makers—Pottery Makers—Cement Makers—The Textile Industries (Wool, Shoddy, Cotton, Linen, Jute, Hemp, Rope, Cocoa-nut Fibre, Fustian Clothing, Silk)—Brush Makers—Wood, Horn, and Ivory Makers—Artificial Flower Makers—Paper and Wall-paper Manufacture—Flour Makers, Bakers, and Confectioners—Flint Millers—Sand and Glass Paper Makers—Makers of Silicate of Cotton—Grinders of Basic Slag.

OCCUPATIONS INVOLVING THE INHALATION OF ABNORMAL QUANTITIES OF DUST.

IN practically every occupation a certain quantum of dust is produced, varying from a minute, almost imperceptible quantity, the effects of which are of no importance, up to an amount so large as to be readily appreciable by the worker,

and then the results are very serious. The number of lives lost annually is so great, and the amount of illness is so extensive, that any study of the methods which can be contrived to do away with or diminish the evil becomes of vast importance. It may be said at once that the abolishment of disease due to dust is an ideal only—nothing but the cessation of the trades in which dust is created could do that. It must content us, therefore, to do what we can to lessen the very serious dangers to life and health which are caused by the inhalation of abnormal numbers of minute atoms of matter floating in the air. When much dust arises in any particular occupation and is breathed in, it passes right into the lungs, and it is to this fact that the industrial dangers are all due. The demonstration of the ease with which the tiny specks can penetrate into the lung is simple. It is common for ultramarine workers, who inhale a good deal of the blue dust of ultramarine, to spit up blue-stained sputum for a fortnight after ceasing work, showing what a store must have accumulated in the lungs.

It has long been a recognised fact that to breathe in for any considerable time minute solid particles is productive of various diseases of the organs of respiration, such as bronchitis, asthma, chronic pneumonia, and chronic phthisis (consumption), whatever may be the origin of the atoms entering the lungs, some much more seriously and much more quickly than others. The sources and nature of the dust of trades are many. It may be of vegetable, animal, or mineral origin; it may be fine or coarse, smooth or rough, poisonous or non-poisonous. Thus the dust of ground white lead is very fine, smooth, and highly poisonous; the dust of flour is fine, smooth, and non-poisonous; the dust of a wool manufactory consists of non-poisonous filamentous particles;

the dust of Portland cement is non-poisonous and very fine; and so on. The nature of the atoms is of importance, sharp, angular particles such as that of tin mines being much more injurious than soft rounded particles such as flour dust.

The symptoms of all these dusty lung diseases, known by all sorts of names, such as potter's lung, grinder's rot, stonemason's lung, and so on, are as follows. The onset and course is a slow one. Bronchitis, with cough and expectoration, often with black particles of dust, is the commencement. The health gives way—appetite, colour, and flesh fail, difficulty of breathing follows, and finally, if the disease is not checked, general destruction of lung may take place, the health is undermined, and death ensues.

The channel of entry of the dust is through the nose and mouth during the act of breathing—the particles are drawn into the lungs, and, unless removed by expectoration, remain to do their deadly work.

The avoidance of the appalling mortality from dusty occupations, if it cannot be done away with, may certainly be diminished by the adoption of a few common-sense precautions. They may be summed up in a few words: lessen the amount of dust produced or scattered, and prevent that which is scattered from getting to the lungs. To accomplish this object, the ventilation of all rooms and workshops in which dust is generated in large quantities should be carried out in a thorough, efficient, and scientific manner, and all the sanitary arrangements should be as perfect as possible; for it is important that the workman should keep his health at the highest pitch possible, in order that he may be able to resist the attack of the dusty atoms on his lungs. The sections on ventilation, sanitation, and

the maintenance of health (Chap. VI.) should be consulted in this connection. No meals should be eaten in the work-rooms—for here the food would get covered with dust, and so be rendered unwholesome.

All the machinery should be arranged in such a way that as little dust as possible is scattered around, either by covering it up or connecting it with revolving fans and shafts to remove the particles by means of currents of air.

Respirators should be worn in all those occupations or manipulations in which much dust, or very fine dust, is produced. There may be a certain amount of discomfort connected with this, but the risk to life and health is so great that no inconvenience would be too arduous, considering the saving of life and health obtained. A few words on respirators in general will be appropriate here. Many respirators are heavy, hot, and uncomfortable, besides being expensive and readily wearing out. It is important, for the convenience of the wearer, and as an inducement to him to use them, that light, comfortable, cool, well-fitting, durable respirators should be chosen. The examination of properly constructed respirators which have been used in a dusty workshop readily proves that a great deal of dust has been intercepted by them; at the same time, it cannot be disputed that they do present certain disadvantages—and the most important of them is the fact that, however well made they are, they do impede respiration. They make a man breathe quicker, get hotter, and perspire more abundantly, and then the result is that with a bad respirator he tends to inhale more dust, and to swallow more dust, than he would do without one at all. But still, on the whole, the discriminating use of well-made respirators does prevent the inhalation of many of these minute atoms, and notwithstanding certain inconveniences the balance is on the side of the respirator,

provided it is kept nice and clean, and prevented from getting clogged. Dr. Dupré recommends, in place of either the metallic framed respirators, respirators made from woven or knitted stuff, or pieces of flannel or sponge, which are the usual forms of these instruments, small bags of fine cambric, the mouth of the bag being large enough to cover the nose and mouth. The following is the form of respirator advised, in Dr. Dupré's own words:—

Small bags made of fine cambric, the mouth of the bag being large enough to go over the nose and mouth.—In some cases a flexible wire was passed round one half of the mouth of the bag, by means of which it could be fitted fairly closely over the nose. In others, the opening of the bag was large enough to go nearly up to the bridge of the nose, and could be made to fit fairly closely. These bags are light; the cambric of which they are made, though not absolutely dust-tight, is fairly so, and they do not interfere so much with the breathing as the other varieties. The discomfort they cause is relatively slight, and the workpeople accordingly have not so great an objection to wear them. The foremen therefore succeed more readily in enforcing their wear. Great care, however, is necessary in tying them over the mouth and nose, otherwise they do not fit tightly enough to the face, leaving a space on each side of the nose through which, rather than through the cambric itself, the inspired air passes, carrying with it the dust. This want of fit is greatly aggravated by any movement of the head of the worker, particularly while stooping. In several instances in which I have examined bags after they had been worn for some hours, I have noticed that, while the greater part of the interior surface of the bag was free from dust, a very appreciable amount had adhered to the inner side, near the edge of the mouth of the bag. These bags are thus by no means perfect, but they are, I think, a move in the right direction; there is, however, a tendency to make them too small, probably to suit the fancy of the girls, who do not like to look funny or ridiculous. However natural such a feeling may be, it should be resisted for the

sake of the welfare of the girls themselves. Within reasonable limits, the larger the bag the safer it will be. Another point which has not been sufficiently attended to in most cases is the method of securing the respirator to the face. In most instances only one pair of strings or elastic was used for this purpose. Now it is impossible fairly to secure a respirator over mouth and nose unless at least two pairs of strings, fixed to different parts of the respirator, are attached to it, one pair of these to be tied high up over the head, the other low down or round the neck. By such means only is it possible to ensure that the respirator does not move about with every movement of the worker. In most cases I have observed that, where the respirator was worn, it hung so loosely that it was practically entirely useless.

A perfect respirator should have the following characteristics :— It should prevent all access of dust to the mouth and nose, and perhaps cover the ears; should not interfere with the breathing or work of the wearer, and should touch the skin of the face as little as possible, since the friction between the skin and the respirator, particularly when the wearer perspires, as is almost invariably the case, facilitates absorption, the perspiration tending to catch and fix the dust to the face. The cambric bags above described, when of sufficient size, nearly fulfil these requirements, but it might be worth while to try whether a veil, attached to the head, covering all round, and falling some distance below the chin, but gathered loosely round the neck—particularly if the headgear had a projecting rim, like a hat—might not be an improvement. Such a veil would, at the same time, serve as a cover for the hair and ears, which are at present left in great part unprotected.

If once the symptoms of lung disease arise, the course to pursue must be the immediate removal of the worker from his dusty occupation. The disease itself can only be treated by medical men.

The following is a list of some of the most important of the very many occupations in which dust is generated in

large quantities and is liable and likely to be inhaled, with the comparative mortality from lung disease of these occupations :—

	Consumption.	Other Diseases of the Lungs.	Total Lung Diseases.
Coal miners	126	202	328
Carpenters and joiners	204	133	337
Bakers and confectioners . . .	212	186	398
Plumbers, painters, and glaziers .	246	185	431
Masons, builders, and bricklayers	252	201	453
Wool manufacturers	257	205	462
Cotton manufacturers	272	271	543
Quarrymen (stone and slate) . .	308	274	582
Cutlers	371	389	760
File makers	433	350	783
Earthenware manufacturers . .	473	645	1118
Cornish miners	690	458	1148
All males (England and Wales) .	220	182	402
Fishermen	108	90	198

It will be noticed that at both ends of the list miners stand. Those with the highest death-rate from lung disease, nearly three times that of all males taken together, are the Cornish tin miners; those with the lowest, even less than that of the general male population, are the coal miners. This difference is accounted for largely by the nature of the dust inhaled—sharp and angular in the case of the tin mine dust, that of the coal mine mostly free from sharp particles.

Coal Miners.—There are many varieties of workmen employed in coal mines, and the industrial mortality and diseases vary not only according to the nature of the work, but also to the kind of mine—whether well or ill ventilated, whether the temperature is high or low, and so on. The dust may be pure coal dust, which is then very fine, so fine indeed that it may spontaneously explode, or it may be mixed more or less with stone dust. But it is certainly a curious thing that coal miners, with their unhealthy dust-inhaling work, with their breathing of impure air at a high temperature, with their underground dark occupation, in the damp and wet, and in constrained unhealthy postures, should have such a low death-rate from lung diseases. Dr. Ogle suggests that coal dust has a special power of hindering the development of the germs which cause consumption. But this is improbable, and it is more likely that the explanation lies in the fact that, to begin with, the miners must, from the nature of their work, be a healthy picked race of men, and also that so many fatal accidents occur in coal mines that there are not enough miners left for the death-rate from other causes, *e.g.* respiratory disease, to be very large. In the case of miners there is very little the workman can do to diminish his liability to dust inhalation and its consequent ills. This rests almost entirely with the managers and onwers. Proper and efficient ventilation has reduced and will further largely reduce the liability. The workman should, by observing common-sense rules as to the preservation of his health, keep himself in the best condition possible, so that he may counteract the effects of his underground occupation (see Chap. VI., section on preservation of health).

Sweeps, Coalheavers, and Trimmers.—In connection with coal dust a few words must be said about one or two other

occupations in which this substance is inhaled, namely, those of sweeps, coalheavers, and trimmers. In all these a certain amount of coal dust is breathed in, and the mortality from lung disease is consequently higher than that of the general population—it is, in fact, considerably higher than that of coal miners. Practically nothing can be suggested whereby we can avert this evil. The workman must keep himself in the best possible state of health, so that he may battle against the ravages of the dust, and great attention must be paid to personal cleanliness.

Sweeps, besides the lung trouble described above, are also liable to eczema and sore eyes from the irritation of coal dust. Here is the place also in which to mention that the disease to which sweeps are very liable is cancer in some of its forms. Of 242 sweeps who died, 49 were from cancer, and this death-rate is five times the average mortality of the general population from this disease. The cancer may affect many different parts, but is most frequent in the scrotum, and is probably caused by the constant irritation of the soot at this part.

The liability to eczema and sore eyes may largely be avoided by strict attention to ordinary personal cleanliness. Considering the very great frequency of cancer, it is well worth while to adopt any means which may prevent it, even if some trouble is entailed. With this object the scrotum should be frequently washed, and no dust allowed to remain long there and irritate the part.

Charcoal dust, which is respired by charcoal grinders and colliers, steel makers, and bronze moulders and casters, produces the same illness that the inhalation of coal dust does, and needs no further remarks.

Lead, Copper, and Tin Miners.—Of the various forms of

metalliferous mining those just enumerated are the only ones carried on in this country to any extent. They are all attended by a very high rate of mortality from chest diseases, caused by the dust inspired: which is the more dangerous it is difficult to say. Perhaps the chief reasons of the high mortality of those engaged in these mines, when compared with coal miners, are, firstly, that the mines from their nature are more difficult to drain and ventilate than are coal mines; secondly, from the fact that the dusts are metallic and poisonous, and composed of sharp, angular, irritating particles; and thirdly, that explosives are used in these mines, which generate poisonous gases and cause the formation of large numbers of minute stony atoms. They, however, do possess one advantage over coal mines—they seldom produce explosive and poisonous gases, and can therefore be worked safely without lamps. In lead mines the ore chiefly mined is galena, a sulphide of lead, and the dust of this occasionally, though not commonly, gives rise to lead poisoning (see p. 44). Dust is also produced during blasting operations, and whilst the various strata of limestone, sandstone, and shale, especially the latter, are being cut through. The importance of the perfect ventilation of these mines from the health point of view can hardly be overestimated; the comparison of the deaths from lung trouble in the workers in two mines, one of which is properly, the other improperly ventilated, amply proves the advantages accruing from the removal by ventilation of the dusty atmosphere. In tin and copper mines the dust is produced, again, during the blasting operations, and whilst cutting through the various rocks,—nothing need be added to what has already been said above on lead mining.

Quarrymen engaged in taking out stone, slate, etc., have a

high death-rate—582 compared with 402 for all males—from lung diseases, the danger of the occupation varying with the physical and chemical properties of the dust created. In the various quarrying operations for obtaining alabaster, graphite, and china clay, the particles produced are not sharp or angular, and the effects of inhalation consequently not so very serious. It may here be noticed that the minute fragments of graphite are also breathed in during the manufacture of lead pencils.

In chalk and limestone quarries the work is carried out so much in the open air that the dust is largely got rid of before it is inhaled, and the occupation does not appear to be a very risky one. Slate quarrying is the most formidable of all, as here the atoms are so sharp and pointed, and it is among those who are occupied in the sawing and dressing of the stone, where the dust is specially freely produced, that lung disease is most rampant.

The only special remark as to prevention is this: during any operations in which much dust is created, respirators should be worn.

Masons, Builders, and Bricklayers suffer slightly more than the general population from lung trouble, the death-rate being 453 compared with 402. In these occupations a good deal of dust is raised during the mixing of the mortar and cement, or whilst sawing stone and smoothing and dressing it with chisels. This especially applies to hard, flinty stones. But those engaged in the working of marble and granite are not very great sufferers in this respect. Probably the outdoor nature of the work provides an efficient and thorough means of ventilation, and this accounts for the comparative freedom from lung disease. The dust is blown away before it is inhaled. But unfortunately this comparative innocuousness

of granite and marble does not apply to stones in general. Most of them are very harmful, especially the stone known as Edinburgh stone—here the mortality from "stonemason's lung" is appalling.

In the manufacture of millstones from French burr by the use of chisels and hammers, a great deal of noxious dust is generated; but this is an occupation almost obsolete. The use of steel rollers has done away to a large extent with the necessity for millstones. (See also article on "Eye Accidents.")

Sheffield Trades.—In the occupations which involve the use of grindstones and emery wheels, such as cutlers, needle and pin makers, tool grinders, grinders of razors and sword blades, in fact in all those combined trades known as the Sheffield trades, the workers are exposed to the dust scattered by the grindstones, sharp pointed particles which may consist of either stone or iron, and cause the lung affection known as "grinder's rot,"—in cutlers, one particular branch of grinders, reference to the table shows that their death-rate from lung affections is 760 compared with 402, the standard for all males.

The processes of the manufacture of cutlery are thus carried on. The worker sits upon his "horse," and, leaning forward, presses the article to be ground, say a knife blade or a razor, against a rapidly rotating stone. This causes numerous particles of metal and stone to be freely thrown about. They are inhaled by the workman, leaning right over the wheel, and are particularly injurious from their jagged and rough character. If the grinding is "dry grinding," it is plain how much more the atoms of metal and stone will be scattered than if the "wet grinding" process is employed.

The unnatural and unhealthy position adopted by the workers of leaning forward so much, gives rise to various affections, such as lumbago and sciatica, which can only be avoided by not adopting this position: the worker should so arrange his "horse" and wheel that he may sit upright.

The articles having been ground, must be polished, and this is carried out by means of leather-covered wheels, revolving at a high rate of speed, on which various powders are used for polishing.

The dust then arises in many ways. Firstly, there is the dust due to the process of smoothing the stones, which must be frequently repeated as they wear away; then there is the dust of both stone and metal made during the actual grinding of the tools; and thirdly, there is the dust given off during the polishing on the leather-covered wheels, caused by the use of polishing powders, such as emery, pumice, or rouge. It will be readily understood, from what has already been said, how the very high mortality rate from chest diseases is brought about in these workers.

To avoid the inhalation of dust in the Sheffield trades, special attention should be paid to carrying it away by means of fans or shafts placed in such a manner that the air current set up sucks away the injurious atoms of stone and metal as they are thrown off from the grindstone. There is no doubt, from carefully carried out experiments, that the amount of dust from a workshop, say for instance in a grinding mill, can be very materially reduced by a well arranged and properly constructed fan. One of these experiments may be quoted with advantage. The conditions of the room in the two instances mentioned below were precisely similar, with this single exception that in the first the fan was not working and in the second it was.

The amount of dust which collected in a certain time and in a certain position when the fan was stopped was seven times the amount which collected in the same position and in the same time when the fan was working.

In addition to the fan, wet cloths may be placed over small wheels to catch the little atoms, and the amount inhaled can also be lessened by the position adopted by the worker: as a rule the one he selects is a bad one, and one in which he is placed in the most favourable posture for breathing in dust. He leans right over the wheel, bending his head into the thick of the dusty atmosphere. He should, as far as possible, avoid this unhealthy position.

Attempts to lessen the amount of dust produced should be also made by reducing to a minimum the polishing powder used, and by substituting as far as practicable the wet for the dry grinding process. Grinding may be either wet or dry, and obviously in the latter the dust produced is larger in amount than in the former. The mortality of file grinders, for instance, which is a wet grinding occupation, is much less than that of fork grinders, a dry grinding trade. But in making the smaller articles this wet grinding cannot unfortunately be employed: thus in the manufacture of needles, and so on, the dry process must be used. As to the use of respirators, the remarks on respirators in general should be consulted (see p. 4). The advantages in point of health amply repay any slight inconvenience entailed by their use. The experiments above mentioned prove the necessity of wearing them; they show that, however efficient the ventilating apparatus may be, it cannot draw all the little harmful specks away; some are still left in the air for the workman to breathe and to do their mischievous work.

For the remaining dangers connected with grinders, see articles on "Grindstones" and on "Eye Accidents."

It may be mentioned, *en passant*, that needle grinders are subject very frequently to rupture (ventral hernia), from the excessive labour of cutting the bundles of wire. This should always be done by machinery instead of by hand. They also suffer from a form of paralysis of the hand muscles, from the great strain on them in holding such small things as needles during the grinding operation. Rest from the occupation should be taken for some time under these circumstances, and some other avocation pursued, and a medical man should be consulted.

Just a few words must be added respecting a few special branches of the Sheffield industries. File making is shown by the figures in the table—the mortality from lung disease being 782 as compared with 402 for the general population—to be a very unhealthy trade, but here the risks of lead poisoning overshadow any other danger of the trade, and the subject is treated of at p. 44. Fork grinding, which is a dry grinding process, is a very dangerous branch. A few figures will show this. In England and Wales, out of every 1000 deaths, 160 took place between 20 and 30 years of age. In Sheffield the rate was 184 for the same age, and among fork grinders the rate was 875—that is to say, five times the rate for the whole country, and more than four and a half times the rate of the whole town of Sheffield. Again, the death-rate of the kingdom was, for ages between 20 and 40, 296 per 1000; in fork grinders the rate was 885, *i.e.* three times the rate of the kingdom at large. Out of 61 fork grinders who died, 35 died before reaching their thirtieth year, and 47 of them under the age of 36; not one of them reached 50 years of age.

With razor grinders, scissor grinders, and penknife

grinders, the processes not being entirely dry grinding processes, the mortality rate is lower. Compare, for instance—

Fork grinders—of 1000,	885 died between 20 and 40 years of age.			
Razor ,,	,, 749	,,	,,	,,
Penknife ,,	,, 731	,,	,,	,,

Table-knife grinders, saw grinders, scythe grinders, file grinders (the processes in all these operations being of the wet variety) are more healthy—the death-rate is lower.

One more set of figures will help to prove the greater danger attaching to the dry grinding process; the average age of death was—

In fork grinders	29 years.
In razor ,, ...	31 ,,
In scissor ,, ...	32 ,,
In table-knife ,, ...	35 ,,
In saw ,, ...	38 ,,

Needle making is of necessity a dry grinding process. It is much the same as that already described, but, owing to the large number of small articles ground, the amount of metallic dust created is very large. The pointing and the polishing are the two most dusty operations. The use of fans with suction tubes removes a large proportion of the dust, and wet cloths placed above the wheels catch a good deal.

Fish hooks and steel pens are made in practically the same way.

Dr. Arlidge examined two specimens of dust from a needle-grinding workshop: in one from a bench he found

95 per cent. of stone and 5 per cent. of iron, in that from the dust house 96 per cent. of steel and only 4 per cent. of iron—that is to say, that the fans, etc., over the bench were very efficient in extracting a very large proportion of the steel atoms produced.

Electroplaters.—A few special remarks must be made on the subject of electroplate making—not the actual plating, but the subsequent polishing process; this has to be accomplished by the friction of rapidly revolving wheels covered with leather and sprinkled with polishing powder of emery or rouge. Consequently dust is generated in large amount, just as it is in the use of grindstones.

During the process called "spinning," where a hollow ware article, such as a dish cover or mug, is produced from a flat piece of metal by friction with a steel tool on this metal, revolving at a very great rate, dust is produced in practically the same way as in the use of grindstones. In these occupations the precautions to be taken are those just referred to under "Grindstones" and the "Sheffield Trades" (p. 12).

Mother-of-pearl Makers.—During the cutting, turning, drilling, and polishing of this substance, the workers inhale the sharp, irritating dust produced, and the breathing of these fragments is rendered more easy by the position adopted by the workmen of leaning over their machines. In addition, irritation of the eyes from the dust, and a form of inflammation of the bones, etc., commonly called rheumatism, from absorption of the material of which the mother-of-pearl is composed, occur in these workers.

As to the avoidance of these dangers, all that has been said under "Grinders" applies. The eyes of those who find

any signs of inflammation developing must be guarded by some form of eye protectors.

Pottery Manufacture.—The manufacture of china and earthenware is one of the most deadly trades of this country. A reference to the table shows that the deaths from lung diseases is, with the single exception of the Cornish miners, the highest in the list, the figures being 1118, compared with 1148 for the tin miners and 402 for the general population—that is to say, nearly three times as many as all males together.

Although the dust from potter's clay is not so harmful as the dust of the Sheffield trades, the dangers and death-rate of the occupation as a whole are very much greater than in the grinding trades. This is very largely due to the terrible disease and mortality from lead poisoning.

The figures quoted below are important as showing the immense room there is for improvement in this manufacture. From a number of cases investigated, the mean age of death of male potters over 20 was 46½ years, of other males in the same district 54 years. The most common causes of death were chest diseases, diseases of the heart, consumption, and also nervous diseases. Potters suffered from chest diseases at the rate of 12 per cent., other workers at the rate of 8 per cent. only. Heart disease affected potters at the rate of 4 per cent., other workers only to the extent of 2 per cent. Consumption was present in 12 per cent. of potters, only in 9 per cent. of other workers. These figures conclusively show we are dealing with a very unhealthy occupation indeed, and therefore it is necessary to carefully ascertain if anything can be done to render it in any way safer.

The trade consists of two essential departments—the manu-

facture of the various articles, cups, jugs, basins, plates, etc., from the clay, during which large quantities of dust, consisting of sharp, pointed pieces, are scattered; and secondly, the finishing of the articles by painting and gilding, in which the chief danger is from some form of mineral poisoning, especially lead. For remarks on the second part of this subject, the reader is referred to the articles on "Lead Poisoning," p. 44.

The first portion, the actual making of the articles, here alone concerns us. All forms of pottery, whether china, earthenware, or porcelain, are manufactured from some form of plastic clay, mainly in the Staffordshire district. The clay used by potters is derived from felspathic rocks, which have been decomposed and the finest portions washed away and collected in hollows in the earth as beds of various thickness. Chemically it consists of silicate of alumina in combination with water, together with small quantities of potassium, sodium, lime, and iron.

There are four materials necessary for the manufacture of pottery—ball clay or blue clay, kaolin or china clay, crushed flints, and Cornish stone. The various quantities required are different according to the kind of ware, but the principle is always the same. The foundation is blue clay, and the flints are for whitening; kaolin is added to arrest the whitening and to make the vessel less liable to break, and the Cornish stone is used as a flux. Plaster of Paris and calcined bones are also employed to some extent in the trade.

The first operation consists in grinding such of the substances as are not in a fine powder into a minute state of subdivision. Then the materials are mixed with water, and pressed into a solid clay. The shaping follows—the vessels must be smoothed, dried, and hardened—they are then printed, if they are to be decorated, glazed, and finally fired.

This is a very brief outline of the manufacture of a china vessel; one or two of the processes must be described a little more fully.

The careful grinding of the materials is very essential, for good pottery cannot be manufactured unless the materials of which it is made are reduced to a very fine powder. The different substances are ground in water in separate pans until they can pass easily through fine silk lawn, then allowed to stand and the excess of water removed, and afterwards subjected to pressure to get rid of the rest of the water, leaving the clay. After the vessel is roughly fashioned, it must be smoothed. This is done by turning on leather in the case of hollow ware, and by rapid rotation on a small table and rubbing with tow in the case of flat articles. When removed from the boxes or saggers in which it is fixed, the vessel must also be scoured to remove surplus dust from it.

During the mixing process a large amount of dust is produced—dust from the siliceous and ordinary clay, from the flints, felspar, plaster of Paris, and the calcined bones; many of these particles are sharp, angular, and a potent source of the lung disease known as potter's lung. The workers who do the scouring or brushing after the removal of the articles from the saggers produce immense dust clouds, and inhale the noxious particles, and the same applies to the various work-people engaged in the different smoothing operations referred to above. The men who perform the firing inhale a lot of dust from coal and from the articles of pottery. When the saggers, too, are emptied, plenty of minute specks of all sorts are raised. From the above, it will be readily seen how in so many of these operations dust is created and distributed, and thus the mortality from lung disease is so high, especially when the injurious characteristics, the sharp and irritating nature of the dust, is considered.

But very few special points as regards prevention need be discussed here. Little remains to be added to what has already been said on prevention in general. But the advantages of a perfect system of ventilation are nowhere more apparent than here. The operatives object to the usual means—they seem so often to prefer to work in hot, dusty rooms; but if fans are used they not only remove the dust, but at the same time ventilate the rooms without draughts.

Respirators would be of the greatest benefit, if the operatives could only be persuaded to see their advantages and wear them. In the scouring process the manipulations should be done within boxes which almost enclose the vessels, and the dust taken away by fans. The mixing should be performed in covered tanks, and long-handled stirrers used, so that any dust that is made may be to some extent prevented from escaping, and that which does escape may be at some little distance from the breathing organs of the workman, and not directly under his nose, as it would be if too short stirring rods were used. Whilst smoothing the articles, the machines used should be connected with fans, which will create a draught and draw away the dust.

Cement Makers.—Those engaged in the manufacture and use of Portland cement are very liable to get the dust into their lungs. Portland cement is made from some substance containing carbonate of lime, such as white chalk, existing in such immense quantities in this country, and some material containing silica and alumina, such as a selected clay, or alluvial mud. These are ground together with water to a muddy consistency, which is then dried by heating in chambers. This being a wet process, no dust is raised, but during the next stage, the digging out of the cement, a great deal of dust is created. The material raised is then calcined, ground

between rollers, and finally packed in bags. In the last two operations, the grinding and packing, much dust is also scattered. The particles are of a sharp, irritating character, and therefore dangerous.

As to prevention, the grinding should, as far as possible, be done in mills, in which the machinery is covered to prevent the dust escaping. During the digging out and packing processes the men should wear respirators, and the bags in which the cement is put should be of such a nature that the fine cement dust cannot readily escape. It is better, too, that the filling should be done by machinery, just as it is sometimes in flour mills.

It may be mentioned that cement workers, like sweeps and mother-of-pearl makers, suffer from inflammation of the eyes from irritation of the dust; any workman who shows the least tendency to this should wear some form of eye protector.

Destructive ulceration of the nose is not uncommon in the case of these men, from the local action of the particles on the nose. Any suspicion of this should be met by the employment of respirators to prevent the dust getting into the nose, and a medical man should be consulted as to the treatment of the ulceration.

Textile Industries.—This is a large and very important group of occupations, and needs some considerable amount of attention. Here the particles of dust are of quite a different character to those already considered, being of a filamentous nature—not sharp or angular—but yet the mischief they can do is still very considerable.

Reference must also be made to the section on "Arsenical Poisoning" in the textile trades at p. 82, to that on "Lead Poisoning" at p. 54, and on "Chromium Poisoning" at p. 98.

Woollen Manufacture.—By wool is meant the hairy covering of animals, which besides being softer than the hair itself, is also of a wavy character. The chief animals which supply us with wool are—first and foremost, the sheep, and then the Angora goat, the llama, alpaca, vicugna, and the camel. The wool of these animals is used by the spinner, the weaver, the felt maker, etc., to produce various fabrics. In the first place, the bales are opened and the sheared fleeces are sorted out into eight or ten heaps, depending on the quality, by a workman known as a wool stapler. To do this, he must pick each individual fleece to pieces, lock by lock, and throw each lock into its proper heap. This operation must be done by hand, and during its continuance it is obvious that a lot of fine particles of wool are scattered about and breathed in by the workers.

The wool must now be washed or scoured to get rid of the natural greasy secretion called yelk, and also to clear away the dirt in it. This is done by putting the wool into a long trough partly filled with a warm alkaline solution, which removes the grease. The raw material is dragged through this mechanically and squeezed nearly dry, and then washed in clean cold water to get rid of the soap formed by the grease and alkali. It is next thoroughly dried, and afterwards passed to a dusting machine, which disentangles the locks, drives out the dust, and blows the wool through in a beautiful flocculent state. As it passes through this machine a fine spray of oil plays upon it, to prevent it from becoming over-dry. During these various manipulations, the wool being in a wet state for the most part, there is little risk of dust creation excepting in the dusting machine. Here, if a proper apparatus for carrying away the dust is not used, dangers may arise.

The wool must now be carded if woollen cloths are

required, or combed if worsted goods are wanted. These operations are performed by machinery, which disentangles any knots and lays the fibres out in a continuous film. It is then gathered into a small compass by passing through a ring and rubbed into a cylindrical twisted cord. These cords pass to the spinning machine, and here go through a large number of manipulations, unnecessary for our purpose to describe, in one of which it is covered with size to prevent it from chafing, and finally the woollen cloth is produced.

If it is dyed before carding, this is done after it is washed. It is then beaten by machinery with a plentiful supply of soap suds, again washed and dried, and the nap or pile raised. If worsted goods are wanted, the machinery in use is different, but no detailed description is needed. It is sufficient here to point out that it is during the early operations, especially the sorting and combing, that the dust is created and the danger arises.

For the risks connected with the printing and dyeing processes of this and other textile industries, the reader is referred to the articles on "Lead and Arsenical Poisoning," pp. 54 and 82.

The precautions to be taken to prevent lung disease from dust inhalation are those which have already been fully described under dust diseases in general. They are, briefly, proper ventilation, the covering of machinery and the use of revolving fans, and the wearing of respirators. It is an undoubted fact that of all the textile manufactures the woollen is the least harmful, probably largely because of the fact that oil is used during the process, which prevents the escape of dust. In connection with this trade the article on wool-sorter's disease should be consulted.

Shoddy Manufacture, etc.—In the various trades in which

old woollen materials are converted into fabrics fit for use, much dust is created, and in much the same way as happens in wool factories. The dirty old rags are first sorted, the woollen from the cotton and linen, and here much dust is of necessity raised. The sorted rags are then torn up by machinery, and this again is a dirty, dusty occupation. But now as a rule the machines are covered in and provided with rotating fans. The materials are then carded, and subsequently go through various manipulations to complete their conversion into cloth; but as oil is added to it after the carding process, the production of dust practically ceases then, except during the manipulations necessary for raising the pile in dry cloth.

To obviate these dangers, the unsorted rags should first of all be well washed and the dust extracted by exhausting fans, so that, when they come to be turned and pulled about during sorting, there may be only a minimum of dust to escape and vitiate the surrounding atmosphere. Machines properly constructed to prevent the scattering and diffusion of the particles of hair should be used, and the remarks on ventilation and the use of respirators, made when dealing with dust diseases generally, carefully followed.

Manufacture of Cotton Goods.—The spinning comprises the various processes by which the raw cotton is converted into yarn, to be subsequently woven into cloth. This is, of course, in the present day, practically entirely a machine process. It is not so dangerous an occupation as that of linen manufacture, but more so than that of wool.

The first operation is a hand one. The bales, which have been imported in a very compressed state, are opened out and well mixed by workmen; during the manipulations a large amount of dust is raised. The cleansing, or the freeing from

foreign substances, such as seed, etc., is performed by two machines—the opener, which tears it apart, and the scutcher, which beats out the dust. The feeding of these machines is done by hand, and the workers here must necessarily inhale a good deal of dust. After this, the cotton is formed into flat folds in another machine: the next operation is that of carding, or straightening the fibres which are made parallel in the drawing machine: the twisting process, and the conversion into yarn, is completed in various machines, into the mechanism of which it is unnecessary to enter. The yarn must now be wound on bobbins, and here a large amount of fluffy dust is given off. Sizing follows, which is done to prevent the filaments breaking; then the weaving process is commenced, during which operation dust from the china clay so commonly used in sizing is diffused.

In most of these manipulations, especially the early ones, the opening, mixing, and cleaning processes, and also in the weaving operations, the dust of filamentous particles is diffused through the air, forming a potential source of disease to the workers employed.

There are other important sources of dust which must not escape notice here. There is the mineral dust of the china clay, which is especially injurious; there is the dust made during what is known as gassing, which is the passage of yarn, which is required to be very smooth, through a small flame of gas, to burn the rough portion off. The atmosphere around becomes filled with specks of scorched cotton. Lastly, the rotating cylinders of the carding machines are covered with sharp spikes; these soon become clogged and blunted, and require frequent cleaning and sharpening. Much dust is raised during the process, repeated several times a day. Mechanical devices have been invented to

perform both the cleaning and the sharpening of the cylinders, and these should be adopted in all works, to minimise the scattering of dust.

The prevention of these dangers can be largely managed by a few simple devices. The necessity for thorough ventilation must be once more insisted upon; this, with machinery provided with covers and fans to prevent the escape and diffusion of the dusts, will to a large extent prevent the onset of respiratory diseases. The old-fashioned size, made of fermented flour and tallow, is better than that made from china clay, as it creates no dust. Respirators should be worn during the dusty parts of the manufacture (see p. 4). See also "Lead and Arsenical Poisoning," pp. 54 and 82.

Linen Manufacture.—The conversion of flax into linen is a very important industry, attended with a good deal of dust diffusion, and consequent injury to the lungs. It is, as in the other textile industries, in the early stages that the dangers chiefly arise, and it is of them all the most pernicious.

After the flax is gathered, the woody matter must be separated from the fibrous portion, which is the only useful part, by the process of setting, which usually consists simply in steeping the plants in tanks of water. It must then be scutched or crushed between rollers. Here an immense amount of dust is produced; but the conditions of labour in Belfast, the centre of this industry, are such that the men are only occupied at this work for a very small portion of the year, the rest of their time being spent as agricultural labourers. The introduction of improved machinery, too, has done away with a large part of this evil.

The flax is now roughly combed, to remove foreign matter and lay the fibres fairly regularly, then gathered into bundles which are fixed in the claws of the heckling machine,

in which the short and long fibres are separated and rendered parallel. In this operation much dust, which is of a fine consistency, and contains 13 per cent. of silica, is produced.

The long flax has now to be prepared for spinning, and the short tow must be carded to get it ready for the same process; in both of these manipulations, especially the latter, dust once more arises.

There are four main divisions to complete the production of linen—spinning, weaving, bleaching, and printing. Spinning may be either wet or dry. In the wet spinning, which is the one always adopted in Belfast, the stuff is drawn through troughs of hot water. The wetting prevents to a large extent the dust escaping, but it is attended with the bad results of wetting the clothes and feet of the workers and making the atmosphere very damp. If the spinning is of the dry kind, as in the Scottish factories, the evils of wet are avoided, but much more dust is produced.

Weaving is the operation of converting the yarn into cloth: it is warped by machinery, then sized to prevent it breaking. Fortunately the use of china clay sizing has not been introduced into this industry, and therefore the evils which exist from its use in the cotton trade are non-existent. The next process, that of beaming, consists in winding the warp round the warp beam—then the material is finally woven.

Bleaching or whitening the linen is performed preparatory to printing, and need not detain us, as no injurious dust particles are created.

If the linen has to be dyed, the cloth is immersed in the dye stuff. When the dye is soluble in water, a mordant which fixes it on the cloth in an insoluble condition must be used: alumina, oxides of tin, protoxide of lead, black oxide of copper, are all used as mordants. The printing is generally

done by machinery, and after this the various finishing processes are gone through; for fuller information on this part of the manufacture of linen, refer to "Arsenical and Lead Poisoning," pp. 82 and 54.

Various diseases of the skin may arise in some of the departments. The irritation of the oil, which is used very freely in lubricating, in combination with neglect of personal cleanliness and the rubbing of the skin with the hard corduroy trousers, is one cause of this; and contact of the hands or feet with water in which flax has been soaked for any length of time is another cause.

It will be seen that in the linen manufacture a good many risks are run by the workers. There is the chief danger—dust inhalation; and there are also the risks from the continual wetting and breathing of moist and damp air, the danger of metallic poisonings, and of skin diseases.

It is in the early stages, the preparing and carding, that dust is produced in the largest quantity, but it is by no means confined to these processes. The dust is a fine, irritating one, and all steps possible must be taken to prevent its production and diffusion. The heckling machines should be covered in and provided with revolving fans. The carding rooms should have jets of steam blown into them to settle the dust. Ventilation should be properly carried out, and respirators worn (see p. 4).

The risk of rheumatism and colds from the continual wetting and moisture can be lessened by wearing mackintosh aprons or overalls, and by the provision of splash boards. The rooms, too, should be large and lofty, and well ventilated, as that will prevent the air from becoming unduly charged with moisture.

Metallic Poisoning: for this, refer to articles on "Arsenic" and "Lead," pp. 82 and 54.

The skin diseases can be avoided by taking care not to keep the hands, etc., for long in contact with the flax water, and by preventing the machine oil getting on to the various parts of the body.

Jute manufacture is similar in principle to linen making, but as the fibres of the two are somewhat dissimilar, so are the various processes. The most important difference is due to the fact that as the fibres of jute are not very flexible, it is necessary at an early stage to soften them with water and train oil, and this to a large extent prevents dust diffusion. The heckling machine is not used in jute manufacture, nevertheless dust is produced. Its dangers and the precautions to be taken are the same as those for linen making.

Hemp is used for ropes, cords, and carpets. The manufacture is much the same as jute. Here also no heckling machines are used. In carpet making the hemp is cut into twelve-inch lengths, oiled, and then scutched, carded, and arranged in slivers. The coarse fibres and woody matters are removed, and the rest converted into tow. The slivers are made into large bales, which are again passed through the finishing card, by which fresh tow is separated. Wool is also an important ingredient in this industry. After the hempen foundation is made, short-fibred coarse wool, wound on bobbins, is woven in. All these processes produce dust of hemp and wool; especially is this noticed during the emptying of the tow box, and also during the dressing process, particularly of hemp imported into this country.

Carpet beating when done by hand raises an immense dust: the outdoor nature of the work prevents much evil consequence arising from it. Nowadays machinery is

generally used, and here the dust should be properly carried away by exhausting fans.

Rope.—The hemp must be sorted and picked over, hand roughed and heckled; then carded and a sliver formed, twisted and spun either by the wet or dry process. In all the early stages, especially sorting and heckling, dust is produced just as it is in linen making.

Cocoa-nut fibre, used for matting, etc., also gives rise to a good number of rough fibrous particles, and all that has been said as to the industrial affections connected with flax and jute applies equally to hemp and cocoa-nut fibre.

The Manufacture of Fustian Clothing.—The cloth is stiffened with flour paste, then stretched on a frame and dressed with liquid slaked lime. The worker inserts the point of a long knife under a thread of the weft, and carries it swiftly along the cloth. Dust of lime, flour dust, and fluff is produced and inhaled, and causes the usual signs of dusty lung disease.

Silk Making.—This is the least health-destroying of all the textile trades, and it is practically only in the working of waste silk that risks are run. Silk waste is derived from the refuse of best silk, or else from the defective and dirty cocoons. The waste is first boiled in a soapy fluid to remove the "gum"; it is then placed between cylinders, covered with rows of teeth to separate and tear up the fibres. It is in this dressing process that the dust is chiefly created, and, although in good factories the machines are as far as possible enclosed, this cannot be done in the case of all of them.

The silk, owing to its difference from high-class silk, must also undergo the process of gassing, *i.e.* the running of it rapidly through a flame to burn off the fluff. As in other textile industries, the gassing is attended with the production of much dust of burnt materials, and consequent injury to health.

What has been said as to prevention in connection with the other textile industries applies here equally. The proper ventilation, covering of machinery, provision of fans, and the use of respirators, is all that is required to practically abolish any likelihood of the inhalation of abnormal quantities of dust. In this occupation more easily than in any of the other textile manufactures could this result be accomplished, and trade risks practically abolished (see pp. 3 to 6).

Brush Makers.—The horse hair and bristles, etc., as imported are in a very dirty state. After boiling, they require to be beaten and combed, and here a large amount of irritating dust is raised. When the bristles have been fixed in, they must be cut level, and to do this plaster of Paris is often used so that the scissors or shears get a proper grip. Here dust both from the plaster and the cut bristles is evolved.

The preventive measures are, firstly, not to employ plaster of Paris—it really is not necessary; and secondly, to use respirators during the brushing and combing processes. The workrooms should be properly ventilated (see Chap. VI.).

Wood, Horn, and Ivory Manufactures.—Here, during sawing, drilling, and polishing, dust of various kinds is created and inhaled, lead poisoning may arise, and naphtha vapour from the varnish may be breathed in and cause poisoning.

Sticks, umbrella handles, etc.—The wood is first cut by circular saws, and in the process the hard woods, such as ebony and rose, cause a deal of dust to fly. The harder the wood, the more is the dust. Soft woods give rise to very little of it.

The wood is shaped and turned, and then smoothed and polished. The smoothing is done by friction with sand paper, and much dust, especially of the sand, is raised.

Varnishing finishes the stick—the varnish is composed of shellac dissolved in naphtha spirit with a little red or white lead. If enamelling in addition is required, still more lead is used in the composition.

The manufacture of such wooden goods as brush handles, spindles, bobbins, and chairs are all during the sawing, boring, polishing, and smoothing operations accompanied by the production of much dust, especially again in the case of hard woods. The use of sand paper for polishing also adds a certain amount of mineral dust to the wood dust, and thus renders it more noxious.

Carpenters, joiners, turners, and cabinet makers are exposed to the risks of breathing in wood dust; but the lung disease death-rate—337 compared with 402 for all males—does not seem to prove that much harm is caused by its inhalation.

Makers of matches inhale the dust of the wood used for the match splints, but this causes little harm; the chief danger of those workers is phosphorous poisoning (see p. 143).

In the manufacture of horn and ivory goods, *e.g.* buttons, knife handles, billiard balls, brush handles, etc., the cutting, turning, and polishing processes are all accompanied by dust of horn or ivory, and this is more irritating than the wood dust, and causes more disease. The danger peculiar to

all these is the inhalation of dust—dust of wood, ivory, or horn, mixed with sand dust.

The prevention is the same as already described—respirators, ventilation, and fans to remove dust whenever possible (see p. 3). In the varnishing and enamelling other dangers arise—*e.g.* the inhalation of naphtha vapour (see "Indiarubber Manufacture" for dangers due to breathing naphtha), and lead poisoning (see p. 44) from the white or red lead contained in the enamel or varnish. This danger might easily be prevented by using zinc oxide instead of lead in the varnishes, etc. It makes an excellent substitute.

The Makers of Artificial Flowers may inhale the dust which arises during the opening out of the stamped-out leaves, and also during the dusting with potato flour for bloom, or with glass dust for frost. The wearing of respirators, and the efficient ventilation of the rooms, would do away with this (see p. 3). See also "Arsenical Poisoning," p. 81, and "Mercurial Poisoning," p. 93.

Paper Making.—At no long distant period paper was mainly made from old rags, whereas at the present time such substances as straw, old rope, esparto grass, and fibrous peat are used.

The dangers which arise in the manufacture of paper are much more serious in the case of that made from old rags than in that made from grasses, etc., and therefore at the present day are not so important as they were, owing to the large employment of these grasses.

The first sorting of the old rags is conducted at the rag and bone shops. After they are received at the factory, the sacks are emptied, and the coloured separated from the

white rags; they are then torn to pieces by the "devil" machine and boiled to a pulp. In all these various processes dust is scattered in the emptying of the sacks, in the sorting, in the moving of the rags to the cylinders, and in the use of the devil machine.

All that need be insisted on in the way of treatment, beyond that mentioned at p. 3, is the necessity of adequate ventilation of the sorting rooms, the use of respirators if much dust is created, and the employment of properly constructed "devils," to hinder, as far as practicable, the dust escaping.

The paper is bleached by the use of chloride of lime, or of chlorine gas, and here the dust of bleaching powder or the vapour of chlorine may escape, be breathed in, and cause poisoning. (See pp. 109 to 112.)

In the sorting of the rags it may be mentioned that various contagious diseases may be conveyed to the workers by handling of the old rags—*e.g.* scarlet fever, smallpox, or even anthrax (see p. 147). To guard against this, the rags should be subjected to some preliminary treatment with an antiseptic of some sort, such as chloride of lime or carbolic acid.

The Manufacture of Wall-papers.—The paper must first be placed on cylinders, unless received in rolls, to allow it to pass with facility through the various machines. The ground colour is then spread on the paper, and for this purpose it is passed between rollers and through a shallow tank of the liquid ground, and under brushes to spread it uniformly. It is carried automatically to the drying place, and there hung up in strips to dry. This drying is done at a high temperature, and as a rule the drying room is not separated from the other workrooms. After the paper is

dry it goes through various processes for printing its colours and patterns.

In the completion of the paper there are several operations, such as glazing, bronzing, flocking, and mica-dusting, according to the kind of paper required, to which it is necessary to devote some attention.

Glazing.—This is employed when silky-looking papers are required: the paper is glazed after the colour is put on by means of French chalk from a machine, during which operation a large amount of dust is generated.

Bronzing.—This is generally carried out by hand. The pattern is stamped in size, and whilst still wet the workman dusts on the bronze powder by means of a soft pad. Very thick clouds of this bronze powder are thus raised. This powder is composed of copper, zinc, and arsenic. The size used contains white lead.

Flocking.—When velvety-looking papers with a dull, rough surface are needed, the paper is first stamped with size or some sticky material, and then put into a large kind of box with a canvas bottom, to receive the sprinkling of flock, which consists of very finely chopped lamb's wool or old cloth ground to a fine powder. The flock is distributed by beating the bottoms of the boxes with sticks, and here again dust is created in large amount.

Mica-dusting.—This is used for producing the sparkling appearance of glass or broken granite on paper. The mica dust, which is chemically silicate of magnesia, is put on in the same way as flock is, and makes dust clouds in the same way.

The colouring of wall-papers is treated of under "Arsenical Poisoning."

The dangers which belong to this occupation are several. There is, firstly, the inhalation of particles of

solid matter floating in the air; secondly, the risk of arsenical poisoning; thirdly, the danger of lead poisoning; fourthly, the evils arising from working in an overheated atmosphere.

The dust arises during all the four processes referred to, viz., glazing, bronzing, flocking, and mica-dusting, and consists of French chalk, lamb's wool, cloth dust, metallic particles, and mica dust.

The preventive measures are as follows: the boxes in which this flocking and mica-dusting are done should be provided with accurately fitting covers, so that they may prevent the egress of dust.

A very efficient machine has been invented, whereby the mica dust is put on to the paper without causing much danger. The paper passes into a box containing the mica. This box has a perforated bottom, and is kept in motion by a wheel and lever and fed by a hopper. After passing through this box, the dusting-off process is performed by machine brushes. All the machines are covered over and connected with revolving fans and pipes, which suck the dust away. There is no doubt that this does very materially diminish the number of particles in the atmosphere.

Wet bronzing should, whenever practicable, be substituted for dry bronzing, but this is only possible when the work is coarse. It cannot be managed for the finer class of papers. Dry bronzing machinery has been invented, very similar to the mica-dusting machine described above. It is certainly very serviceable in reducing the amount of dust in the air.

Respirators should be worn, and the rooms properly ventilated (see p. 3).

The metallic poisonings are treated under "Lead and Arsenical Poisoning" (pp. 44 and 84).

The last danger we have to consider is that caused by the high temperature of the workrooms. It has been mentioned above that the room in which the papers are dried is not separated from that in which the other operations are carried out, or at any rate by only a few feet. The temperature of the drying room is often at 90° F., whilst that of a healthy room should be only at 60° F. The result is that the operatives have to work at a temperature which is much too high, and this is a very unhealthy thing to do. This can be easily remedied by having the drying rooms quite separate from the other rooms, and by having any room with a high temperature ventilated by means of revolving fans, which will considerably reduce the temperature.

Makers and Users of Flour.—Flour grinding is carried on in windmills or watermills. The wheat must first be cleansed, and this is performed in various ways. The one thing common to them all is the production of large quantities of dust. This is not the only part of the process in which dust is produced. In the cleansing and filling of the sacks more is raised. Until the introduction of steel rollers and automatic machinery for grinding the wheat, the particles of flour were freely scattered; nowadays this is, by the new machinery, almost abolished.

The few points special to the prevention of the flour-grinding dangers are as follows. The cleansing and crushing machinery should be covered and provided with fans and dust chambers, the pipes of which must be cleaned out at intervals. The beating of sacks for cleaning purposes should be performed out of doors or else under a dust-extracting fan, and filling is best performed by means of a machine called a sack jumper.

Bakers and confectioners are exposed to a certain extent

to the dust of flour, but the death-rate from lung diseases in them does not show that the comparatively small amount inhaled causes any harm.

Flint Millers are a small class, but suffer terribly from lung disease. Flints are obtained either from chalk pits or from shingle. They are then calcined and ground to powder, and it is during this process that the dust is inhaled.

The workers should certainly wear respirators during the grinding operation (see p. 4).

The Manufacture of Sand or Glass Paper.—In this occupation the sand or glass is ground to a fine powder, and then passed through a fine sieve on to paper covered with some adhesive material. Dust of a very sharp and irritating character is produced at all stages, and, even when the sifting is done by machinery instead of hand, it is impossible to prevent some escaping. To prevent the access of dust to the lungs, respirators should be worn, and the rooms well ventilated (see pp. 3 to 6).

The Manufacture of Slag Wool (silicate of cotton).—This substance is used for packing pipes from engines and boilers, for laying between floors to deaden sound and to render them fireproof, for cold storage purposes, etc. This is a very limited industry, and a few words will suffice to describe the process and its risks. Molten slag is allowed to flow in a fine stream, either direct from the furnace, or from a vessel in which it is re-melted. This fine stream is met by a strong blast of steam through a narrow pipe, which causes the formation of small particles of slag. These are driven into a chamber at a high rate of speed. The viscous nature of the particles and the rate at which they are travelling causes

them to be prolonged into thin threads, which in the mass is called slag wool, or silicate of cotton. The raw material, the slag, is composed as follows:—

Silica	32·45
Lime	31·23
Alumina	24·79
Iron protoxide	0·77
Magnesia	7·03
Calcium sulphate	3·72
Phosphoric acid	trace
	99·99

The wool itself is a non-conductor of heat and sound, and is non-inflammable. It is very light indeed, so that its particles readily float in the air. This quality, the extreme lightness, allows the very ready dissemination of the atoms of wool, and constitutes the sole danger of the occupation. The risk does not occur during the actual manufacture, for no one can be in the room where it is being produced, of course, on account of the steam; but when the stuff is being packed the chamber is full of minute light floating atoms of silicate of cotton, and these particles are readily inhaled.

But very few additional words can be added to what has been said already on the prevention of dust inhalation troubles. The chamber in which the cotton has been manufactured should not be entered until plenty of time has been given to the slag-wool dust to subside, and respirators should most certainly be worn by the packers (see p. 4).

The Grinding of Basic Slag.—Basic slag, obtained in the manufacture of basic steel, is ground into powder for use as

a manure. It is, as left in the converter, in large pieces, which must be reduced to a small size before it can be utilised. Its composition is as follows:—

Lime	45	per cent.
Oxides of iron	18	,,
Phosphoric acid	18	,,
Magnesia	6	,,
Silica	6	,,
Manganese protoxide	3·5	,,

with alumina, vanadium, calcium, and sulphur.

It must be ground into very fine powder indeed, so that it would pass through a mesh 10,000 to the square inch. The machinery, on account of the hard nature of the slag, must be of a very powerful kind, and, owing to the amount of vibration and the very fine nature of the dust, it is impossible to prevent some considerable quantity of it being liberated. A good deal, too, escapes as it is being packed in the bags.

The danger of the occupation is simply that common to dusty occupations in general—there is nothing poisonous in the particles, as will be seen from the above analysis.

The preventive measures are also in the main those already fully described. It is especially important that the workers should wear respirators or veils, on account of the very fine nature of the dust, and therefore the ease with which it will penetrate the lungs. Care should be taken to ensure that the bags used for packing should be made of such a material that the escape of dust is prevented effectually. The shoots, where the ground slag is packed, should have cowls and fans arranged to properly draw away the dust created; and no meals should be eaten in the dusty rooms (see pp. 3 to 6).

The users of various iron salts, such as the phosphide, the peroxide, and the protoxide, for polishing and colouring, those who employ polishing powders (emery, pumice, etc.) or ultramarine, and so on, all may inhale the dust of these various substances; but they need not be referred to in detail, as they present no special features.

A brief mention must be made of workers in arsenic (*e.g.* those occupied in making wall-papers and artificial flowers), workers in lead (*e.g.* lead-mill hands, painters, and plumbers), and workers in copper mines, all of whom inhale dust; but here the industrial diseases produced are due to the metallic nature of the dust, to the articles on which reference should be made.

There are also a very large number of other occupations in which dust production is a minor factor, many of which will be referred to briefly in the course of succeeding chapters.

From all that has been said on this subject, it will be seen that the diseases which are due to the inhalation of abnormal quantities of dust arise in a very large number of and in some very important occupations—that the sum of the loss of life and loss of health in all these various occupations reaches figures which are almost alarming—that although it is impossible absolutely to prevent the dust reaching the lungs, and so setting up its diseases, yet this can be to a large extent accomplished by paying attention to a few simple principles—and that every precaution, even when irksome, is well worth taking, when we consider the results in saving of life and health which may be attained.

CHAPTER II.

TRADES IN WHICH THERE IS DANGER OF METALLIC POISONING.

LEAD.—Lead Poisoning in General—Lead Miners—Lead Smelters, Melters of Old Lead, etc.—Red Lead Makers—White Lead Makers—Painters and Colour Grinders—The Textile Trades—Weaving—Earthenware and China Manufacture—Glass Polishing and Glass Cutting—Type and Note Founders and Setters—Makers of Lead Glass—File Cutters, etc.

ARSENIC.—Arsenical Poisoning in General—Manufacture of White Arsenic—Preparation of Artificial Flowers—Textile Industries—Fellmongering—The Makers and Users of Arsenical Pigments—Manufacture of Wall-papers and other Papers—Bronzers, etc.

MERCURY.—Mercury Poisoning in General—Workers in Quicksilver Mines—Workers in Gold and Silver Mines—Makers of Philosophical Instruments—Mirror Makers—Vermilion Makers—Furriers—Photographers—Bronzers—Gilders—Hat Makers—Telegraphists—Artificial Flower Makers—Sole Stitchers by American Machinery.

COPPER.—Copper Poisoning in General—Clock Makers—Bronzers—Filers, Turners, and Polishers of Copper—Those engaged in cleaning and repairing Old Copper, Boiler Tubes, and Vessels.

ZINC.—Zinc Poisoning in General—Extracting Zinc from its Ores—The Manufacture of Zinc Oxide—Zinc Wire Workers—Galvanised Iron Workers.

CHROMIUM.—Calico Dyers and Printers—Dyers of Silk, Linen, and Wool—Painters on Glass and Porcelain—Makers of Coloured Papers for Bonbons—Bichromate of Potash Makers.

BRONZING.

BRASS.—Brass Founders, Casters, Turners, Filers, and Polishers.

METALLIC POISONING IN GENERAL.

THE three chief metals which are responsible for industrial poisoning are lead, arsenic, and mercury. There are, of course, a large number of others which more or less rarely

give rise to instances of poisoning, but compared with the first mentioned they are insignificant. Thus, in the five years ending 1890 in England and Wales, 1822 *deaths* from accidental poisoning were recorded. Of these, 541, or about 30 per cent., were from lead, 17 from arsenic, and still fewer from mercury. The amount of illness it is impossible to estimate; but as in 1897 over 1200 cases of lead poisoning were recorded (and this only represents a small proportion of the actual number that occur), it is seen how very frequently the metals act as a cause of danger to life and health. Anything that can be done to diminish the death or disease rate becomes of importance, and every effort should be made both by employers and employed to adopt every possible precaution. Lead poisoning in the potteries and the means which have been taken to prevent it is a good illustration of the saving of life and health which follows from a thorough scientific study of the question, and the application of the results of this study to a practical trade.

Lead Poisoning, or Plumbism.—This metal is so largely used in various industries that occupations in which the danger of lead poisoning arises are very numerous. A few of the more common forms of employment in which this disease occurs may be enumerated: these include painters, plumbers, file cutters, pottery workers, lead-mill hands, glass polishers, lead smelters, dyers, weavers, colour grinders, glass cutters, compositors, and note founders. The subject is a very important one, for every year many deaths and a great deal of illness, entailing a large amount of suffering and misery, are caused by the poison, much of which could be prevented by a little knowledge of the way in which the dangers arise. In 1897 no less than 1214 cases of lead poisoning from occupation were recorded. After treating of the subject

in general, a few words will be devoted to each particular trade, and any special points in connection with it will be dealt with.

There are three channels of entry of the lead into the system—(1) by absorption through the mucous membrane of the alimentary canal (the mouth and stomach); (2) by inhalation of dust or vapour containing lead or its compounds through the mouth and nostrils to the lungs; (3) by the skin. This last method of entry is doubted by some, but the great probability is that it does get into the body by the pores of the skin in minute quantities. We may illustrate these remarks more fully by referring to the work of particular workmen, say plumbers. These workmen use either lead in the pure or almost pure form, such as gas and water pipes, or as an alloy—for example, solder composed of lead and tin, or as compounds of lead, such as red lead (oxide of lead) or white lead (carbonate of lead), used as cements for the joints of iron pipes and other purposes. Brass, too, is used by plumbers, and generally contains lead, as it renders the metal more easy for turning and filing purposes—so that the possibilities of poisoning, even in one trade only, are numerous.

1. By the mouth. The plumber after finishing his work goes home to take his meal. Either from want of time, from laziness, or some other reason, he neglects to wash his hands, or does so but very imperfectly, with the result that every morsel of food he handles is liable to be contaminated by the white lead, or red lead, or whatever it may be, which is on his hands. He takes up a piece of bread, for instance, and soils it with a fraction of a grain of lead; these fractions of grains, by constant repetition, amount to grains, and thus in the course of time a sufficient quantity is introduced into the body to cause lead poisoning. Or his mouth may have become dirtied with little particles of poison, and at the first

drink he swallows the impregnated saliva, and this is carried into the stomach, and poisoning started. Even a plumber who is particularly cleanly may allow the entry of the poison by means of his mouth; he may, for instance, hold nails, tools, screws, or other articles which are soiled with some compound of lead between his lips, and thus constantly introduce minute particles of the poison. But of all the ways a plumber contracts the disease, eating with unwashed hands is the most fertile.

2. By the lungs. This is not a very common way for the poison to enter the body in plumbers, but occasionally it may happen: for example, a man may in a job have to do some work in which he causes particles of lead to fly about in the air around him, and he may inspire some of these particles when drawing his breath, or he may inhale the fumes of the solder he is using. In many other occupations, *e.g.* in various forms of printing and dyeing, in which a good deal of the dust of yellow lead (chromate of lead) flies about and is inhaled, this is a more important method of the entry of the metal than it is in plumbing. In the process of file cutting, again, finely divided pieces of lead are caused to fly about and are easily breathed in — and so in numerous other instances in which the dust of lead or its compounds are caused to float in the air.

3. By the skin. This is not at all a usual mode of the entry of lead; but the constant handling of greasy substances, like white lead or red lead cement, may lead to the rubbing in and consequent absorption of small portions by the skin, and the effects are just the same as if it had entered by the lungs or mouth, the constant introduction of minute amounts at last reaching a point where sufficient has been taken in to cause plumbism. Abrasions of the skin, too, make the entry of lead easier by this channel.

The pure metal is not so dangerous as the salts of lead. Those who work in metallic lead, except it is in the presence of large masses of the molten metal, or who inhale fine particles of the lead, seldom suffer. But those who work in the various salts of lead are very liable to be affected. The chief of these salts employed are carbonate of lead, or white lead, which is largely used as a paint; red lead in the form of massicot, litharge, or minium; yellow lead, or chromate of lead; brown acetate, or brown sugar of lead (made by dissolving litharge in crude acetic acid, and evaporating till it crystallises), used in dyeing and printing; sulphide of lead, or galena, used for glazing pottery or bricks; and nitrate of lead, made by dissolving litharge in hot dilute nitric acid, employed in cotton dyeing and calico printing to produce yellow or orange colours.

Lead poisoning is due to the constant entry of minute particles of lead or its salts into the system: the frequent repetition of small quantities in time amounts to a large quantity—sufficient to give rise to the signs of poisoning.

It is impossible to say what quantity of lead is sufficient to cause poisoning. It is the repetition of small amounts that causes it, but what this amount must reach before symptoms arise cannot be determined—it is different for each individual. Of two workmen exposed to exactly the same risks, one may suffer quickly, the other never all his life.

A few words must be devoted to the symptoms characteristic of the affection; for it is important that the workman should recognise or suspect his illness as early as possible, the prospect of cure being greater, and the duration of treatment shorter, the earlier the disease is recognised. The commonest and principal symptoms of plumbism are constipation, which is very obstinate and difficult to relieve; pain in the stomach of a crampy or colicky nature, which is often

made better by pressure; a pale colour of the parts of the body which are generally well coloured, such as the lips and the inner surface of the eyelids; the characteristic blue line on the gums due to a deposit of a lead compound, lead sulphide, in the tissues, just where the gums and teeth meet; paralysis of various muscles, especially of the wrists, known as dropped wrist; and pains in the joints, generally spoken of as rheumatics. Degeneration of the kidneys and liver, and lung disease, is very common in lead workers. The onset of one or more of these symptoms should make the workman at once suspicious of something wrong, and should lead him to consult his medical adviser immediately.

The precautions to be taken to escape from the attacks of plumbism are not very irksome, and yet of the utmost importance. When any little trouble is entailed, it should be remembered that health and perhaps life are at stake, and that the risks of a long and severe illness may be avoided by taking a slight amount of care and trouble. The ideal, of course, would be to abolish all hand work in the various industries in which lead is used, but this is in many impossible, and in most impracticable.

Of all the precautions to be adopted, personal cleanliness is by far and away the most important. Overalls should be worn, which should fit tight round the wrists and neck, for the purpose of preventing the fine dust of lead or lead salts from permeating all the clothes. The overalls should be removed when the work is finished, and should be frequently washed. The hair, nails, and beard should be kept short, so that they may not harbour particles of lead. Always, at the end of work, before taking any food or drink, the mouth should be rinsed out, to wash away any small quantities of lead that may have got there, the teeth should be well brushed, and the hands should be thoroughly and vigorously

scrubbed with soap and hot water and a hard nail-brush (some hypochlorite of soda added to the water, or turpentine, cleans the hands well); and of course all food and drink should be taken in a room away from the place where the work is done. Warm baths should be indulged in as often as possible. Care should be taken not to put the fingers into the mouth and not to rub the lips whilst working. No workman should work with open sores, as this is an easy way for the lead to get in. The application of some greasy material, such as lard or vaseline, to parts exposed to the contact of such substances as acetate of lead is often of great use in preventing the formation of sores and cracks on the skin. Respirators should be worn when there is much lead dust floating in the air, for the purpose of intercepting the particles on their way to the lungs—this especially applies when the lead dust is very fine and in large quantities, as it is in the case of white-lead packing (see paragraphs on respirators, p. 4). Plenty of milk should be drunk, as this is found—how, one cannot say—to act beneficially. A little sulphur added to it is good. Lemonade made with Epsom salts should be taken of freely. It forms an insoluble compound with the lead in the stomach, etc., which then cannot pass into the system. The formula for this compound is as follows:—

Sulphate of magnesium (Epsom salts) . .	2 ounces.
Water	1 gallon.
Lemon syrup to flavour it.	

Water just made acid with weak sulphuric acid answers the same purpose; and then, in addition, two teaspoonfuls of Epsom salts should be taken two or three times a week.

The workrooms should be kept very clean and frequently

washed and swept, and the floors watered to prevent dust rising. The floors should preferably be cemented or flagged, and all places in which any dust of lead is scattered, such as those described, for instance, under white-lead works and in various textile industries, should be very thoroughly ventilated by shafts, cowls, and fans.

As those who are underfed, who are intemperate, or in ill health, are more liable to be poisoned than those who are the reverse, the workman should have good food, should be temperate, and should keep away from work when he is in ill health.

Exposure to cold should be avoided, and warm clothing worn when at work, especially out of doors or in damp and foggy weather.

The treatment of lead poisoning, after it has arisen, is too serious and important a matter to be undertaken by anyone but a medical man, and the only advice to give on this point is to immediately consult a doctor at the onset of symptoms, or even of a suspicion of the disease, so that the proper remedies may be at once resorted to, and grave or serious consequences thus averted.

A short description must now be given of the trades, occupations, or industries in which the disease we have discussed is liable to arise. In some of these it is rare, in others very common; but in all, the mode of origin, the symptoms, and the precautions are identical. The whole of what has been already said on lead poisoning should be carefully read in connection with each trade.

Lead Miners.—The ore chiefly mined is galena, or sulphide of lead, and this being a very insoluble salt, does not often give rise to lead poisoning. But, both during the mining operations and also whilst washing and sorting galena after

it has been dug out, cases every now and then do occur, and therefore the workers must guard against it.

As to the paths by which the lead enters the body, they are fairly obvious—breathing in minute atoms of lead ore, contamination of the hands from handling it in washing and sorting, and so on, and thus conveyance to the food which is afterwards eaten, and possibly entry through the skin.

The prevention is fully described under "Lead Poisoning in General," at p. 48.

Reference should also be made to p. 9, where a description of the chief danger of this occupation, namely, inhalation of large amounts of dust, is discussed.

Lead Smelters, Melters of Old Lead, etc.—The lead is smelted in a reverberatory furnace, and fumes of lead are produced in enormous quantities. The lead in this occupation enters the body by way of the lungs. Other operatives who are occupied in handling the molten metal—makers of lead type, shot makers, stereotypers, type founders, melters of old lead, makers of lead pipes (which is now done by forcing fused lead round a core by great hydrostatic pressure), those who melt lead to make alloys—also get plumbism, the lead being introduced mainly by means of the lungs. Cleaning the flues of the smelting stacks is very dangerous, and every precaution should be taken by the workers.

The remarks made above on prevention of lead poisoning in general apply here—the great thing to do is to avoid, as far as one possibly can, inhaling the dangerous fumes. Respirators are not of much use in preventing the entrance of fumes—they are only of service in arresting solid particles. Free ventilation and hoods placed in front of the furnace greatly diminish the danger.

Red Lead Manufacture.—Red lead is made by placing the metal in reverberatory furnaces, to which air is admitted. The fused metal must be constantly stirred, and this oxidises it. After the requisite heat is obtained, the red lead is ground and allowed to fall into water, and there worked with rods into a paste, dried, ground, and packed into casks.

During most of these operations there is a danger of lead getting into the body—most of all in the packing process. At this time respirators should be worn, to catch, as far as one can, the fragments of red lead, and so prevent them reaching the mouth and nose of the workman. (See p. 48 for the general precautions to be adopted.)

Manufacture of White Lead.—Plumbism is very common in those employed in white-lead factories. More cases occur in this than in any other lead industry. This substance is made on a very large scale, and by various processes: the old Dutch method, a very dangerous one, is that still most commonly employed. It is as follows:—The pigs are first melted in an open cauldron, from which the lead is ladled out and poured into moulds, finally issuing in flat sheets. The sheets of lead are placed on the top of small earthenware pots, which are partly covered with tan, with the object of keeping the vessels warm. Acetic acid is placed in the pots, and on the top of this layer of vessels another is placed, separated by boards, and on the top of this another, and so on. Gradually and slowly chemical changes take place, and nearly the whole of the lead is converted into white lead (carbonate of lead) in the course of about three months. The white lead is placed in trays, afterwards rolled in mills, and sorted over to remove any lead not converted into white lead, dried in stoves, ground very thoroughly, washed, and finally dried as a

very fine powder. It will readily be seen how anyone engaged in any of these manipulations is easily liable to plumbism. During the melting and ladling process the vapour is inhaled, but it is especially after the lead is converted into white lead that danger arises. When the exceedingly fine nature of the powder, and thus the ease with which it flies about as dust, is remembered, this is not surprising. It is breathed in constantly in minute fractions, it may contaminate the hands, in fact may enter the body by all the channels referred to above. All that has been said on plumbism in general applies here especially (see p. 44), but there are several special points to which attention must be paid.

It should be noted that there are much less dangerous ways in which this substance can be manufactured—*e.g.* the action of carbonic acid gas on lead, either as in Thénard's method, or by the action of carbonic acid given off in the combustion of coke, which are both safer. A special danger of the Dutch method is due to the fact that here acetate of lead is an intermediate product, and this causes cracking of the skin, and leaves raw surfaces for the absorption of the poisoning. To avoid this, the hands should be well greased, and gloves of some sort worn.

But it is the grinding which is most dangerous: this, of course, should never be performed in ordinary open pestle and mortars—rollers are best; and the whole apparatus should be covered, as far as possible, to prevent the death-dealing dust escaping. An exhauster should be provided to draw off any dust that has got loose, and sprays of water should be directed on to the powdered substance. For most purposes for which it is used it would be quite as useful in the form of an oily paste. To grind up with oil it is not necessary to dry the powder at all, as practically all the water is forced

out. Thus the danger of lead dust escaping is almost if not quite done away with.

The pots are frequently, whilst being moved from one place to another, carried on the head: this should not be done, for the powdered white lead so easily can reach the hair, clothes, etc. The sorting operations, when the white lead is turned over to see if any remains unconverted, unless special care is taken, are a fertile source of mischief.

The precautions fully described above must be scrupulously carried out (see p. 48).

The same applies to the filling and cleaning of the drying stoves and the cleaning of the stacks, in all of which operations lead easily enters the body.

Painters and Colour Grinders. — These are constantly exposed to the risk of lead poisoning—their hands, bodies, and clothes are more or less always being soiled with the paints used, many of which contain lead salts. They may get it whilst burning off old paint, and they are also likely to inhale the fine dust of the lead pigments whilst grinding or mixing their colours, and especially whilst using sand paper to flatten the painted surface. The usual salts of lead employed as pigments are white lead (white), red lead (red), and chrome yellow (yellow). Nothing special need be said on this particular occupation; all that is necessary is contained at pp. 44 to 50.

Textile Trades.—A good many of the processes connected with this class of industries are described in the article on "Dusty Diseases," at p. 22, and they will be again referred to under "Arsenical Poisoning," at p. 82, which should be consulted. Here reference will only be made to certain dyeing and printing operations, in which the various

materials are impregnated with colouring matters of different kinds, those containing lead concerning us mainly at this place.

The goods must first be freed as far as is possible from natural colouring matter and all impurities, and then, if necessary, mordanted. They should next be placed in a solution of the colouring matter, and gradually heated to boiling point.

Such colouring matters as the yellow and orange chromates of lead, largely used in dyeing on account of their brilliancy, have no appropriate solvents. The most successful method of using these substances is as follows:—The pigment is ground very fine indeed, and then mixed to a paste with white of egg or albumen, and the mixture printed on the cloth. The fabrics are hung up, and the albumen solidified by steam; the colour is thus mechanically fixed to the material.

One or two of the processes may be described in detail; there are many of them, but they are all essentially the same.

Dyeing of Cotton Yarns.—Lead, as the acetate, is largely used for this purpose—for instance, to produce a light yellow colour. The material is dipped into a solution of lime, then into a solution of acetate of lead, again into a lime solution, then into a vat of bichromate of potash solution, and finally washed in diluted hydrochloric acid. The yarn is then dried and sent to be made into bundles. Here it undergoes a great deal of shaking, and the dust which is given off in considerable quantities is laden with lead.

Calico Printing.—The pattern is impressed with lead salts first, and then the material is passed through a vat of

bichromate of potash solution. Only those parts on which the lead has been impressed take up the chrome, and are therefore the only parts coloured. The goods are dried and then folded. It is during the manipulations of the dried cloth that danger chiefly arises, the lead-laden dust being scattered and inhaled; but also whilst the dyeing is being carried on, the hands, etc., may be the means of conveying the poison. (See also p. 99.)

The best precaution that can be taken to prevent lead poisoning in these textile trades would be the substitution of aniline for lead pigments. This would abolish the danger. The aniline colours are just as good as the mineral ones. If this cannot be done, then sizing the yarn before dyeing, which causes the particles of pigment to adhere more firmly to the fibres, and so prevents them from being scattered, should be adopted. Thorough and efficient ventilation with hoods, fans, and shafts, and the wearing of respirators by the workers, should be insisted on (see "Respirators," p. 4, and "Ventilation," Chap. VI.). The following report, which has already been alluded to, shows the great value of ventilation in such a workroom as the above manufacture would be carried on in; it also at the same time proves the efficacy of respirators.

COPY OF REPORT SENT TO THE HOME OFFICE BY MR. J. H. ROGERS, H.M. INSPECTOR OF FACTORIES, MANCHESTER.

Lead Dust in Respirators.

Some time ago it was suggested to me that particulars of the amount of lead taken up by respirators in a works where chromate of lead dust was formed would be interesting, and I requested the chemist at a dyeworks in my district to have some experiments made on the subject.

The analyses given below were made after three hours' work in

the process of "noddling" (stretching and bundling) hanks of yarn which had been dyed with yellow chromate of lead. The girls who did the work wore indiarubber respirators of the ordinary "muzzle" type, in which was a new sponge that had been damped. Two periods of three hours' work were tried, with exactly the same kinds of yarn and under precisely the same conditions, except that, at one of the trials, the ordinary dust-extracting arrangements, a powerful downdraught from a fan, was in action, and in the other the fan was stopped, and the work done with only natural means of ventilation, the room being lofty and having good window openings.

The results follow:—

In the first case, *i.e.*, when the fan was working, the sponge was found to contain 0·0034 gramme of metallic lead. The colour of the dust was only slightly noticeable on the sponge.

In the other case, when the fan was stopped, the sponge was found to contain 0·02 gramme of metallic lead, and the sponge was quite coloured with the dust; and while the "noddling" was being done the atmosphere in that part of the room was clouded with yellow dust.

These experiments would tend to show, principally, the great efficiency of the dust-extracting arrangements, and also, even with the best extracting appliances, respirators are still necessary, as in their absence an appreciable amount of the poisonous dust is bound to be inhaled.

I am indebted to Dr. A. Stüder, the chemist referred to above, for these experiments, which I believe he has made most carefully.

JAMES H. ROGERS.

3rd February 1897.

The general precautions are described at p. 48.

Weaving.—The looms often used in this country are constructed as follows:—Long cords, 1200 to 6000 in number, known as harness cords, are kept tight by weights at the ends, called lingoes. These are made of lead, and by the

constant friction during the movements of the cords in weaving they are gradually pulverised: the dust is very considerable, as the following calculation will show. About 20 go to the pound, and for 6000 of these that would mean 300 lbs., and if (as is the fact) about 6 per cent. is worn off in a year, this equals 20 lbs. for each loom. When a large number of looms are in the same room, it can readily be seen what a great quantity of lead dust is produced. The remedy for this quite unnecessary evil would be the abolition of lead lingoes. They are dearer than iron ones, and these latter keep their shape and position better than the former.

Pottery Manufacture.—The first part of this manufacture, the actual production of the china or earthenware vessels, has been treated of under "Dusty Diseases," at p. 18. It is only with the finishing part, the decoration of the articles, that we are here concerned.

Printing on pottery is thus performed:—Fine tissue paper has the pattern printed on it, and is laid face downwards on the ware, and the back is rubbed with a roll of flannel. This transfers the print from the paper to the china. The paper is washed away by means of water. The colours must be such as can withstand the action of glazes. They are very various — cobalt, lead, tin, gold, copper, etc. After printing they must be once more fired to fix the impression. Either before or after the printing the articles are glazed. This operation is performed as follows:—Flint, Cornish stone, or sand are mixed with fluxes, such as oxide or carbonate of lead, borax, potash, etc. If all the components of the glaze are insoluble in water they can be ground to a fine powder in water; but if any are soluble they must be rendered insoluble by vitrifying them with some other

substance. The glaze is then laid on in thin coats, another firing must be given to the articles, and then the ornamentation, the painting, gilding, and so on, if it is to be carried out, is done as a finishing touch.

During the arranging of the vessels in the saggers before firing, they require a good deal of handling by the workers. If the ware has only just come from the dippers, it is still covered with wet lead glaze, and therefore the lead can readily foul the hands of those so employed.

The dippers, those who dip the ware in the glaze containing lead, are very frequently attacked with symptoms of lead poisoning; and this is only what one would expect, when it is remembered that their hands are constantly immersed in a liquid containing lead.

The painting process is very much the same as other kinds of painting, but the colours must be of such a nature that they are able to withstand the action of great heat; they are therefore of mineral composition, *e.g.* salts of cobalt, gold, chromium, and especially lead. Most of the painting is done in enamel colours, either on the glaze or beneath it. The pigment is mixed with paraffin, turpentine, some essential oil, or merely water; it is this latter variety of paint that is so very commonly the cause of lead poisoning—it is used for common ware, and daubed on without much trouble. The hands of the workers are readily soiled—the paint dries readily, and much fine dust is given off and breathed in. "Ground laying," by which is meant the colouring of vessels by dusting on the colour with lead as its flux, in the form of a very fine powder, also again readily leads to plumbism.

This industry supplies us with an immense number of cases of lead poisoning annually — 387 examples were recorded from the Potteries in 1896. If, then, any means

can be discovered by which we can diminish or abolish this disease, a great boon will be conferred upon humanity.

Very little need be said beyond that already stated on pp. 44 to 50 as regards the channel of entry and the means of prevention; but there is one very important part of the manufacture of pottery we must fully discuss, and that is the glazing process. As has been stated, nearly all glazes contain lead, and this is such a fertile source of poisoning that the brains of many eminent scientists and manufacturers have been of late employed in endeavouring to discover some means whereby this really terrible evil can be abolished, and it may truthfully be said that the discoveries they have made have brought within the sphere of practical manufacturing, processes by which the evils of lead poisoning may be almost or even entirely done away with in the pottery manufacture. The fritting of lead and the use of leadless glazes are the two means by which we may hope to succeed, and these two methods must now be fully discussed.

Undoubtedly the introduction of leadless glazes, if it is practicable, is the ideal method—if glazes without lead are used, there can be no lead poisoning. But if it is found that leadless glazes cannot be used, if they do not satisfactorily take the place of the present glazes in the ceramic industry, then the fritting of lead, by which is meant the conversion of the glaze into a kind of insoluble glass before it is used as a glaze, by fusing it with borax or silica, and thereby rendering it much less soluble in the juices of the stomach,—then this fritting will without doubt do away to a large extent with the danger of lead poisoning in pottery manufacture.

The views and arguments of the two parties—those who would prohibit the use of lead altogether, and those who

would only prohibit the use of raw lead, and not of fritted lead—are given in full here. The matter cannot be regarded as absolutely settled yet; only time and experience in the use of the two materials can do this. At any rate one great, a very great, step in advance has been made. Practically all are agreed that the use of raw lead in glazes should be prohibited, and that this fertile source of lead poisoning should now no longer be possible; and I believe it will not be long before the ideal object, the use of only leadless glazes, will be attained.

Leadless Glazes.—In January 1899 the editors of the *Lancet* published the results obtained by their Analytical Commission on some leadless glazes.

These results and the views of the Commissioners may be quoted at length here with great advantage. After discussing the question of fritting lead, to which reference will be made later, they proceed to say:—

We next turn to the possibility of doing away with lead altogether. Obviously, could this be done without interfering with the peculiar and delicate requirements of the art of glazing, we might confidently hope for a speedy and satisfactory solution of a very difficult question. An enormous number of laborious experiments have been made on this promising side of the subject, with the result, we may hope, that the introduction and adoption of practicable leadless glazes will become before long an accomplished fact. But obviously nothing short of the evidence of experience can be expected to satisfy the industry on all points. As a small, though we think encouraging and instructive, contribution to the question, we now offer the results of some experiments which we ourselves have made with certain leadless glazes in the *Lancet* laboratory during the last month. We cannot, of course, lay claim to the possession of practical knowledge or judgment in this matter. Our interest in the

question is necessarily a limited one, but it is a vital interest, the points at issue affecting the well-being of those engaged in a beautiful but at present dangerous art.

Our attention was recently drawn to the important results of a great number of arduous experiments directed to the practicability of producing leadless glazes which were undertaken by one who has spent much of his time in the Potteries, and who has an extensive practical acquaintance with the industry. These results have been published by the author, Mr. William J. Furnival, the failures as well as successes being wisely recorded. Some of the successes are illustrated in specimens placed on view, by permission of the Science and Art Department, in the Geological Museum in Jermyn Street. By the courtesy of Mr. Furnival we have obtained some specimens of the glaze and of the wares finished by its means. They consisted of various types, such as saucers, cheese plates, dessert plates, plaques, etc., all of which we have examined, tested, and submitted to experiment.

No. 1 was a leadless glaze marked No. 2855, and described as having been used in the dipping of all the samples of ware marked 2855. Examined for lead, this glaze gave absolutely negative results. Borax was an important constituent. When tried on "biscuit" in the oxyhydrogen flame, a clear uniform glaze resulted.

The second specimen was a saucer one half of which was glazed with lead glaze and the other half with leadless glaze. This appeared to us to be a perfectly successful demonstration of the practicability of using leadless glaze. In appearance the leadless glaze was in every way as good as the lead glaze. Careful chemical tests showed the presence of lead in the one case and the absence of lead in the other.

The specimen taken as a third example was a dessert plate with coloured pattern and gold border. The glaze was excellent, and was free from lead.

These examples will suffice, but we may add that we have examined and tested in all fourteen pieces with satisfactory results. The lead was tested for in two ways. First, on a portion of the

plate a mixture of carbonate of soda and potash was fused before the flame of a powerful blowpipe. The melted mass after cooling was washed off in hot dilute hydrochloric acid, and sulphuretted hydrogen was passed through the solution. There was never any indication of lead in the glazes marked "leadless." As a check on this test the plate was afterwards sprinkled with powdered fluorspar and moistened with strong sulphuric acid and gently warmed. The glaze was thus attacked by the hydrofluoric acid generated, and the lead, if present, would be liberated from the flux. The plate was next flooded with water, and sulphuretted hydrogen was passed through the liquid. This test answered very well with ordinary lead glazed ware, but in no case gave any positive response with the leadless glazed ware so described and placed at our disposal by Mr. Furnival.

We consider that these results are of the utmost importance, for they indicate the probability of satisfactorily substituting absolutely leadless glaze for the old lead veneer without detriment to the beauty and finished appearance of the product. It seems to us, therefore, that the ground should be perfectly clear for action by the Home Office. Either leadless glazes are practicable or they are impracticable. It is for a committee of experts to decide one way or the other, with the evidence of practical trial before them. There is no proprietary right whatever connected with the use of these glazes. Their formulæ are published, and fair practical trial and criticism are invited. We understand that already some large pottery manufacturers and others with a considerable experience of the industry have tried these leadless glazes on a practical scale with excellent results.

It may be hoped, then, that the day is not far distant when the Government will be in a position to demand the abolition of raw lead in glazing, and to compel the adoption of safe "frits," or, better still, leadless glazes, without inflicting any hardship on the potter or causing any hindrance to the pursuit of his art. The alternative is to bring lead poisoning under the Workmen's Compensation Act.

Two months later the following remarks appeared in the same journal:—

"We have seen admirable examples of printed ware dipped in leadless glaze, and it is significant that these results were obtained in trials made upon a manufacturing scale and upon pottery intended to be placed upon the market by leading firms of high reputation." "We have no doubt whatever that leadless glazes of sufficient brilliancy, covering power, and durability, and adapted to all kinds of table, domestic, and sanitary ware, are now within the reach of the manufacturer."—(Professor T. E. Thorpe, LL.D., F.R.S., and Professor Thomas Oliver, M.D., F.R.C.P. Lond., in a report just printed in the form of a Blue-book, and dated Feb. 21, 1899.)

"We next turn to the possibility of doing away with lead altogether. Obviously, could this be done without interfering with the peculiar and delicate requirements of the art of glazing, we might confidently hope for a speedy and satisfactory solution of a very difficult question. We now offer the results of some experiments which we ourselves have made with certain leadless glazes in the *Lancet* laboratory." "We consider that these results are of the utmost importance, for they indicate the probability of satisfactorily substituting absolutely leadless glaze for the old lead veneer without detriment to the beauty and finished appearance of the product. It seems to us, therefore, that the ground should be perfectly clear for action by the Home Office. Either leadless glazes are practicable or they are impracticable. It is for a committee of experts to decide one way or the other, with the evidence of practical trial before them." "We understand that already some large pottery manufacturers and others with a considerable experience of the industry have tried these leadless glazes on a practical scale with excellent results."—(The *Lancet* Analytical Commission on Some Leadless Glazes, the *Lancet*, Jan. 7, 1899, p. 49.)

A more striking and complete confirmation of the views which our Commissioners expressed in these columns nearly two months before the issue of the Government expert's report on the subject than is presented in this first paragraph could hardly have been forthcoming. The Blue-book dated Feb. 21, 1899, is another evidence of the ability of Professor Thorpe and Professor Oliver to

deal with the question of dangerous trades and the means which might be adopted to counteract their evil effects. Last week we dealt with the report of these gentlemen upon phosphorus in the manufacture of matches (they were then aided by Dr. Cunningham, who inquired into the dental aspect of the question), and we said that the joint report was a valuable contribution on the subject, which should enable the Government so to regulate the manufacture of lucifer matches as to place the great number of workers in this important industry under conditions entirely free from reproach. It was concluded that there need be no phosphorus necrosis with regulations strictly yet not vexatiously enforced. The report on lead compounds used in pottery manufacture is equally valuable, and its import equally clear. Professor Thorpe, as in his previous inquiry, visited several Continental factories, and his observations are very instructive, mainly in showing how increased legislative control need not interfere with the interests of the industry. He records further some experiments made in the Government laboratory upon lead compounds used, or proposed for use, as substitutes for raw lead in the pottery industry. The conclusions arrived at as the outcome of the entire inquiry are as follows:—

1. That by far the greater amount of earthenware of the class already specified can be glazed without the use of lead in any form. It has been demonstrated without the slightest doubt that the ware so made is in no respects inferior to that coated with lead glaze. There seems no reason, therefore, why in the manufacture of this class of goods the operatives should still continue to be exposed to the evils which the use of lead glaze entails.

2. There are, however, certain branches of the pottery industry in which it would be more difficult to dispense with the use of lead compounds. But there is no reason why in these cases the lead so employed should not be in the form of a fritted double silicate. Such a compound, if properly made, is but slightly attacked by even strong hydrochloric, acetic, or lactic acid. There can be little doubt that, if lead must be used, the employment of such a compound silicate, if its use could be ensured, would greatly diminish the evil of lead poisoning.

3. The use of raw lead as an ingredient of glazing material, or as an ingredient of colours which have to be subsequently fired, should be absolutely prohibited.

4. As it would be very difficult to ensure that an innocuous lead glaze shall be employed, we are of opinion that young persons and women should be excluded from employment as dippers, dippers' assistants, ware cleaners, after-dippers, and gloss-placers in factories where lead glaze is used, and that the adult male dippers, dippers' assistants, ware cleaners, and gloss-placers should be subjected to systematic medical inspection.

One suggestion in the report is worthy of quotation. It is pointed out that much of the ware supplied to the order of various Government departments, such as the Post Office, the Office of Works, the Admiralty, the War Office, the India Office, etc., could be dipped in leadless glaze without detriment to its character and with no increase to its cost. If in these cases the supply of leadless glaze were insisted upon, it would thereby stimulate the more general introduction of pottery free from lead compounds. We congratulate Professor Thorpe and Dr. Oliver in thus appealing to the Government and putting its sincerity to this most excellent practical test.

We said in the report of the *Lancet* Commission on Some Leadless Glazes that "it may be hoped that the day is not far distant when the Government will be in a position to demand the abolition of raw lead in glazing, and to compel the adoption of safe frits, or, better still, leadless glazes, without inflicting any hardship on the potter or causing any hindrance to the pursuit of his art." We submit that the Government is in this position now.

Messrs. Minton, among other manufacturers, have used successfully, and exhibited, pottery made with leadless glazes.

Mr. Furnival, in his work alluded to above (*Researches on Leadless Glazes.* By W. J. Furnival, Stone, Staffordshire, 1898), gives a large number of practical trials and receipts, and is an ardent advocate of the adoption of leadless glazes.

At an exhibition at Hanley all shapes and sizes of articles

of china, earthenware, porcelain, majolica, and tiles were shown, all made with leadless glazes. Severe tests were applied, but no "crazing" took place. Some of them had been in use nearly five years and were quite good.

The china articles supplied to the Houses of Parliament, the royal palaces, and various other places under Government control, are now compelled to be made with leadless glazes, and private individuals giving large orders are likewise insisting on this as a *sine quâ non.*

The opinions of these experts and the results obtained in actual manufacture seem to me to very conclusively show that leadless glazes are now capable of being made on a practical scale—that these glazes are as useful and as serviceable as glazes containing lead—that their compulsory introduction would not cause any hardship to the manufacturers, and would be a boon of worth to the employés, by abolishing the evils resulting from the entrance of lead into the body—and that therefore we are entitled to demand that the prohibition of the use of raw lead in the pottery trade should be enforced at an early date.

Lead Frits.—The fritting of lead, by which is meant its conversion into an insoluble glass, does undoubtedly diminish largely the chances of lead poisoning, but not to anything like the extent that the adoption of glazes without lead would do. The actual fritting process, of course, must be attended by the handling of lead, and therefore there will be the possibility of danger.

Fritted lead is much less soluble in the acid juice of the stomach, and therefore is not so readily absorbed as raw lead; but all frits are not equally incapable of solution, and a certain standard of insolubility should be insisted on—the more insoluble, the less dangerous it is.

The frit is made by fusing it with borax or silica, and thus converting the lead into a practically insoluble borate or silicate; this frit must then be ground before it can be used. It will be seen that there are several processes during which lead may cause poisoning, especially during the mixing of the lead and silica, etc.; but, compared with the raw lead process, the danger is really a mere trifle.

The consensus of opinion of the manufacturers is undoubtedly on the side of the fritting of lead: a few of these are quoted.

"Fritted lead is as consistent with practical pottery as using the lead in the raw state." "The fritted lead is an easier flux than raw lead." "Fritted lead can be used universally without injury to the trade; it does better for colours, and increases the brilliancy of the wares." "He never knew of a single case of lead poisoning where all the lead was fritted." "Fritted glaze is better for coloured and printed ware, as well as for white ware. Colours used in a glaze which has been fritted are not altered. Even the turquoise blue is fritted, and the colour is not affected."

The managing director of one firm said that it would be advantageous to the manufacturers to frit all the lead before use. When he found that fritted lead was being used for majolica and ornamental ware, and that there had not been a case of lead poisoning in the department, he turned his attention to the matter. Lead must be used. He found fritted lead was quite satisfactory for glazing, both for china and earthenware. The ware is more brilliant, and even with constant rough usage he had not observed a piece yet "crazed." He did not think a rule prohibiting the use of raw lead would injure any manufacturer. A district surgeon stated that at a majolica works in Burslem they use fritted glaze or colour, and the health of the workers is good. Two German manufacturers, after referring to the law in Germany, quoted an instance of

having to pay a dipper who was affected by the lead and lost the use of his eyes. They concluded: "We used to use our raw white lead in the glaze, but, after the experience we had, we now frit it all." Two English manufacturers wrote: "There is not the slightest doubt that the lead is far less dangerous to the workpeople when vitrified. Nevertheless, it is dangerous, and all enamel workers have to contend with illness from lead poisoning, although no free lead is used. The fact is, the acids from the stomach do dissolve glass made from lead. We beg to state we incline to the opinion of the workpeople you mention, that if the oxide of lead contained in the glaze is fritted before being ground for use, the danger of lead poisoning is greatly minimised, if not entirely avoided."

The opinion, then, of men who have made a practical study of this question is sufficient to show that the fritting of lead is consistent with practical pottery; and until the ideal is attained, the prohibition of lead in the pottery manufacture altogether, it should be certainly made penal to use raw lead—it should all be fritted. By this means the danger of poisoning is very much reduced.

As a result of a long consultation between the manufacturers and the experts who were appointed by the Government to carefully and thoroughly investigate the subject of the use of lead in the potteries, the Home Office has recently issued a notice, the effect of which will soon be felt far and wide. It is to the following effect:—It forbids the use of raw lead, and compels the use of fritted lead, giving the manufacturers six months in which to effect the necessary change; it also relaxes the official rules applying to this industry in the case of those factories where no lead, either raw or fritted, is used, but only leadless glazes. The result of this will be in a very short time to immensely reduce the number of cases of lead poisoning in the potteries—a great saving of life, of

health, of suffering—and in a few years' time, when a little more work has been done on the subject of leadless glazes, I am not optimistic in believing that the manufacturers will find it pays, owing to the relaxation of rules, to employ no lead at all, and then lead poisoning will be a thing of the past in the ceramic art—one of the greatest triumphs in recent days of skill and science in abolishing a horrible danger to the workmen employed in a large manufactory. A number of articles on the use of lead in pottery manufacture, and leadless glazes, have appeared in *The Pottery Gazette.*

Glass Polishing and Glass Cutting.—All glass, for whatever purpose it is to be used, whether it be a glass jug or a tumbler, a sheet of window glass, a salt cellar, or a gas globe, must, for the purpose of finishing it off, be polished. This polishing is done upon a revolving wheel, upon which putty powder, or rouge mixed with water, is caused to drip. The wheel revolves very rapidly, and therefore a considerable spray of the moist paste is scattered about. Putty powder is a mixture of about 30 per cent. oxide of tin with 70 per cent. oxide of lead. Rouge is an oxide of iron, generally containing a trace of arsenious acid. Sometimes a hard brush is attached to the outside of the wheels, *e.g.* when any finely-cut work is to be done. The dust produced by the friction of the glass against the wheels also contains plenty of lead if the glass is a leaden glass.

Now it is obvious that the free scattering of a powder containing such a large proportion of lead is very liable to lead to symptoms of lead poisoning, not only in the actual user, but also in those working in the same room. They may inhale the scattered atoms, which may fly on to their clothes, and afterwards dry and be given off as dust to be inhaled, swallowed, or absorbed through the skin.

The following are the few special points as regards prevention, beyond what has already been said on p. 48. Firstly, putty powder can be obtained which contains no lead, but is almost entirely composed of oxide of tin. This is as good as ordinary putty powder, and should be used instead of the lead-containing compound. This, of course, will not affect the lead dust produced by the pulverisation of the actual glass during grinding.

The employers should arrange that the dust should be carried away from each wheel by means of revolving fans and shafts, just as is advised in the case of grindstones (see p. 13). The feeding of the putty powder should be done automatically, and not by hand. When a brush is used, the process should be carried out in enclosed cupboards.

(See also article on "Glass Making," p. 161.)

Type and Note Founders and Setters.—Type metal is an alloy of lead and antimony, and from the constant handling of the type containing lead, from the habit of holding type in the mouth (chewing type), and from the inhalation of the dust in the boxes derived from the type itself, lead poisoning arises. The compositor should carefully avoid the very foolish habit of putting the type in his mouth.

Stereotypers, from ladling the lead alloy, or inhaling the fumes of the melted mass, may also similarly suffer.

(See "Precautions," on p. 48.)

In printing works, "flake white," "snow white," "Chinese white," or metallochrome powder, is sometimes used, and this often contains a large proportion of lead. Of six of these various powders analysed, two were free from lead, three were largely or wholly lead, and one contained but traces. It is used in two ways—as a dry powder for dusting on, or as a liquid in printer's ink. In the dry state it is

generally used for transfers, which are greatly improved by the process of dusting on the metallochrome compound. The powder is first sprinkled on to the sheet, and this is then shaken to distribute it all over, the powder sticking to the part previously printed. Or it may be put on the sheet by means of soft pads, every application of which raises a cloud of dust. Dusting - off finishes off the operation. During the whole of it, dust which, if the powder is a lead powder, is of course full of lead, is raised and breathed. If the wet process is used, no dust is raised, and no risks are run.

The few points as to precautions, beyond those already detailed at p. 48, are as follows:—The wet should always be substituted for the dry process, when it is in any way possible; for this prevents any lead-laden atoms from vitiating the atmosphere, and thus does away with any risk of lead poisoning.

When the dry process is used, good ventilation and exhausting fans to draw away the dust should be arranged for, and respirators should be worn by the employés.

Makers of Lead Glass.—This is made by mixing common sand with oxide or carbonate of lead, and then subjecting the mixture to heat. It is easy to see how, during the mixing process, the lead can enter the system, again either by the hands or to a lesser extent by inhalation.

It may be mentioned, *en passant*, that in the manufacture of coloured glasses other forms of metallic poisoning may arise. These glasses are made by mixing the coloured material with the substances used to form the glass, and melting them together in glass pots. Copper suboxide is used for red coloration, copper protoxide for green; sequioxide of chromium also imparts a beautiful green colour. These pigments can easily be conveyed to the system by means of the hands when engaged in the process of mixing.

Nothing need be here added to what has been said on p. 48 as regards precautions.

(See also article on "Glass Making," p. 161.)

File Cutting.—The dangers connected with this occupation, which is carried on chiefly in the town of Sheffield, are very important—for the mortality rate in this trade is a very high one indeed. File cutters are not a very robust class, and they are very liable to lead poisoning, as the following figures will show. The returns of the Registrar General prove that the deaths from nervous and urinary diseases (mainly due to lead poisoning) in this occupation is 316, as compared with 123 for occupied males in general. The following figures are also of interest. Of 34 cases of lead poisoning treated at the Sheffield General Infirmary in 1894 and 1895, no less than 26 occurred in file or rasp cutters. In this same town in the years 1885–96, 91 deaths were registered as due to lead poisoning. Of these, 48, or about 54 per cent., happened in file cutters or hardeners—figures which conclusively prove that the risk of plumbism, or lead poisoning, is in this occupation certainly not a chimera.

The work is carried out either by hand or by machinery. The machine process is practically devoid of danger. It is only the hand method of file cutting that we need consider. In this trade the worker is seated at a stone block, called a stock, in the centre of which a smaller steel block is so inserted that its surface is raised a little above that of the stock. Upon the steel block, or stiddy, the plain bar of soft iron to be cut into a file is placed. The teeth are cut, each one by a small blunt chisel, struck with a hammer, which weighs from 7 to 9 lbs. A file twelve inches long will require something like 4000 teeth to be cut on it, so that a large amount of work is required to make one file.

About fifty teeth can be cut in a minute by a skilful workman. The file must be supported whilst it is being hammered, and for this purpose a sheet of lead, known as the lead bed, is placed between the file and the steel block, and from nails wedged in between the stone and steel blocks two straps pass over the ends of the file and hang down on the other side, to which a stirrup is attached for the foot to exert pressure, and so keep the file in its proper position in the lead bed. Chalk is used to prevent the lead bed slipping on the stiddy, and charcoal is employed for rubbing into the file before it is turned to the other side. After both sides are finished, the file is vigorously brushed; and so it is easy to see how a good deal of dust of chalk, of charcoal, and of lead is caused to fly about, for each stroke of the hammer and chisel on the soft lead necessarily chips minute fragments off.

The chief dangers of this occupation are—(1) lead poisoning from the lead bed, which is introduced either by means of the hands, which are almost always in contact with the lead bed, and contaminated by constant contact with the particles struck off the lead bed by the blows of the hammer, or else by inhalation of the atmosphere of the workroom, which contains a good deal of lead dust; (2) the inhalation of dust apart from the lead it contains, which is so freely scattered about in the rooms by the constant hammering and brushing of the files—it is composed of chalk, charcoal, steel, and granite. In nearly all these hand-working places the ventilation is bad, the shops are overcrowded and dirty, and thus the evils are increased. In reference to this danger pp. 1 to 7 should be consulted. The pernicious results of dust inhalation, and the precautions to be adopted to prevent these results, are dealt with there.

The following extracts from a paper read by Dr. T. C. Hall in 1865, entitled "The Trades of Sheffield as influencing Life

and Health, more particularly File Cutters and Grinders," show that the dangers of the trade were well understood long ago. Every word he wrote thirty-five years ago is true of to-day :—

In cutting files, it is the custom of the men to wet the thumb and finger of the left hand by putting them to the mouth and so moistening them with their saliva. At every shifting, and when the file has to be turned, the lead is handled, and thus in a variety of ways it is absorbed into the system. They (the men) frequently eat their meals without washing their hands, and often take dinner in the workshop where the files are cut. As though fine lead dust, handling the lead at each shifting, and licking the fingers were not sufficiently poisonous, I saw in one of the file-cutters' shops . . . a man, whose wife had just brought him his dinner, eating it with unwashed hands, and dipping his fingers, blackened and covered with fine lead dust, into a paper which contained the salt for seasoning his beef. I went this day (September 25, 1865) to a file shop in which several men were at work cutting. These men all take their dinners in the shop—they never wash their hands until they get home at night—" sometimes not then." They do not change their clothes when they get home.

After pointing to certain preventives, Dr. Hall concludes his passage on file cutting thus :—

The means of prevention may be considered too simple or trifling; but by these, and a free use of soap and water, how much of pain, of sorrow, and of wretchedness to themselves and to their families, might the file cutters of Sheffield avoid.

Coming down to later times, Dr. Sinclair White, F.R.C.S. Eng., D.P.H. Camb., Lecturer on Public Health, Sheffield Medical School, delivered an instructive lecture in 1893 to the Sanitary Institute in London. He stated that at that time 4000 workmen, besides a large number of women, were employed in the file trade. After detailing the evils which

the Committee have endeavoured to describe, Dr. White proceeds as follows :—

> The ill effects resulting from the employment of lead in file cutting are only too well known. Colic, paralysis of the extensor muscles of the wrist and thumb, gout, and Bright's Disease, are the most evident of its protean evils; but long before it produces these definite maladies its influence on the body is both seen and felt. The sallow, anæmic countenance presented by the file cutter is almost characteristic of his calling, while inquiry will often elicit a history of constipation, indigestion, and bodily weakness long antecedent to the development of more alarming maladies. By way of sampling file cutters, I examined 100 men taken haphazard as I met them in their workshops. Their average age was 37 years, and they had been working at their trade on an average for 23½ years: 74 had a lead line on their gums, 28 had suffered from lead colic, and 20 had at some time been afflicted with paralysis of the wrist or thumb. These figures, however, do not show the full extent of the mischief, because file cutters, when they become seriously paralysed in the wrist, are unable to follow their employment, and either take to some other calling, or too frequently become a burden to the community, until a life of decrepitude and disease terminates in premature death.

Precautions to be taken.—The mode of entry is by all the three channels described in the article on "Lead Poisoning," on p. 44: by the mouth, either by eating with unwashed hands, by swallowing the floating particles, or by contamination of the food from keeping and eating it in the workshop; by the lungs, from inhalation of the leaden particles floating in the air; by the skin, from constant contact with the lead bed.

Beyond the precautions mentioned at p. 48 nothing need be added; personal cleanliness, washing before food, no taking of food in the workroom, and so on, must all be attended to. If it were possible to find anything which would take the place of a lead bed, the greatest danger of

this trade would disappear. But although a large number of substances have been tried, *e.g.* wood, clay, copper, paper, vulcanite, canvas, and various indiarubber and guttapercha compounds, etc., none of them are found in practice to be efficient. They none of them present the right degree of resistance, and so the file cannot be properly cut. The right material has yet to be found.

A mere mention of a few of the remaining very large number of occupations in which every now and then lead poisoning arises, will here suffice.

Cabinet Makers.—Glass paper is used by these workers to a large extent. During its use much fine glass dust is created, and this contains lead, which may be breathed in. Many of the stains used for wood also contain a great deal of lead, which may get into the system from the hands being so often in contact with them. (See also p. 33.)

Jewellers.—The sweepings of the floors, etc., are all collected, so that any gold in the débris may be recovered. A lead alloy is made, and during its use may cause poisoning.

Leather Varnishing.—Red and white lead are used for this purpose, especially in the glacé leather for gloves.

Makers of matches use red lead sometimes as a colouring matter, and get lead poisoning (see pp. 33 and 141).

Those employed in rolling sheet lead, in lining boxes with lead or covering them with tinfoil, enamellers, dyers, brass turners, saw makers, cutlers, tailors, lace makers, straw-hat makers, and those engaged in a great number of other occupations, are every now and then attacked; in fact, in all trades in which lead is used in any way—and they are almost countless—cases sometimes occur. Many of these occupations, in which lead poisoning is a minor factor, are referred to in various parts of this work.

Lead also enters into the composition of the glaze of playing and visiting cards, the glaze of saucepans, artificial jewels, the varnishes used by gilders of wood, the silk used by dressmakers, and so on. It can be seen how anyone using any of these materials may be attacked with symptoms of lead poisoning.

The subject has been dealt with at some length, but its importance can hardly be overrated. The saving of life and health would be enormous if it were possible to use some completely innocuous substance in the place of this deadly metal. Under the head of "Pottery Manufacture" the subject of leadless glazes has been gone into very fully, and this is a good example of what may be done towards the abolition of a serious industrial evil. But, until the ideal of the abolition of the horrible poison from our workshops is realised, we must rest content with doing all that lies in our power to prevent it entering the body and doing its terrible work, by adopting all those means already described under the head of "Prevention."

CHRONIC ARSENICAL POISONING.

Until within comparatively few years arsenic was used in considerable quantities in various trades, such as in the manufacture of wall-papers (many of them containing as much as 60 per cent. of copper arsenite), in some dyeing processes, in the production of artificial flowers, and so on. In fact, so frequent were cases of poisoning by this metal, that the Medical Society of London determined to thoroughly investigate the matter, and appointed a committee for that purpose. Since then, vegetable pigments have to a large extent replaced the arsenical colours; but as a number of cases of illness, or even death, occur still from this poison, we

must consider the subject fully. It must be insisted on that all the soluble salts of arsenic are of a terribly poisonous nature.

The poison may enter the body—(1) by the mucous membrane of the alimentary tract, the mouth and stomach; (2) by inhalation into the lungs; (3) by the broken skin.

1. By the mouth, etc. Eating with unwashed hands, or eating in a room in which arsenical dust has been flying about, or touching the lips, or putting the fingers in the mouth during work, admits the poison by this channel.

2. By the lungs. In manufactures in which grinding of arsenical pigment occurs, dust containing the arsenic is scattered about and breathed in. The constant inhalation of very small portions leads in time to accumulation of sufficient to give rise to the symptoms of arsenical poisoning.

3. By the skin. Any abrasion or sore on the skin allows the poison to get into the blood readily—for instance during the handling of paints containing arsenic, or the immersion of the hands in solutions containing arsenic.

It is necessary for the workman to know what are the common symptoms of this affection, so that he may recognise their early onset and put himself under treatment at once. What is first noticed, as a rule, is some form of stomach derangement—either pain, or a feeling of nausea, or actual sickness. There is, at the same time, either diarrhœa or constipation, headache, loss of appetite, and a general feeling of illness. The eyes become sore, and different skin eruptions appear. Later on, pains in the limbs, and paralysis, falling off of the hair and bronzing of the skin develop, and the patient becomes thoroughly ill, and may die.

The means to be adopted to prevent the onset of symptoms are simple. The workman must be very careful to have no open sores, etc., exposed, and thus leave an easy channel for the entrance of the poison. After his work

is finished, and before touching food, he must take the greatest care in cleaning his hands and nails, by thoroughly scrubbing with a hard nail-brush and hot water and soap. He should keep his hair, nails, and beard short, to prevent the poison collecting in them, and he should not take his food in the room where his work is carried on, for it is liable to be contaminated by particles of arsenic settling on it. Overalls fitting tightly at the neck and wrists, to prevent the poisonous material getting on to his clothes and body, should be worn, and respirators should be used during the work, to stop the dust entering the mouth (see article on "Respirators," p. 4). As many baths as possible should be taken—personal cleanliness is most important in every way. Efficient and thorough ventilation of the rooms should be carried out, to get rid of as much as possible of the deadly arsenical dust.

All these precautions might be done away with if only employers and those responsible would use vegetable instead of arsenical pigments. They are just as efficacious, without any danger. Fortunately this is now being done to a considerable extent, and as a consequence poisoning by this metal is much less frequent than it was.

The following is a list of some of the principal occupations in which arsenic and its compounds are employed, and therefore of the trades in which chronic arsenical poisoning may arise:—

The manufacture of arsenious acid (white arsenic).
The preparation of artificial flowers.
Textile industries.
Fellmongering.
The makers and users of arsenical pigments.
Manufacture of wall and other papers.
Bronzing.

Manufacture of White Arsenic.—A large amount of this is produced annually—from one mine in Cornwall alone some thousands of tons.

The ore from which the arsenic is obtained is called mundic, and is usually an alloy containing iron, cobalt, nickel, and some sulphur in addition to the arsenic. The ore is crushed and then roasted, the sulphur and the arsenic are volatilised, and the vapours conducted through long flues, during which the arsenic is deposited as "soot," and the sulphur passes away by a high chimney. The arsenic is removed from the tubes, crystallised and powdered. It is especially during the removal of the arsenic from the flues that danger arises.

Unless precautions are taken during this removal, the dust of the powder enters the mouth and nose during breathing, and the powder may be conveyed to the food of the workmen. But as a rule the workman performs this task clothed in a leather suit, with glass-covered eyeholes—the breathing orifices, the mouth and nose, being covered with a damp cloth to catch the solid particles of white arsenic. The greatest care, of course, should be taken to prevent any food being defiled by the poison, by paying the most careful attention to washing the hands.

The miners employed in extracting the arseniferous metals are liable to pneumonia and skin ulceration—a large proportion of those employed in the cobalt mines of Saxony suffer from a fatal lung disease, due to the arsenic in the cobalt.

Artificial Flower Making. — The stamped-out leaf is dipped into melted wax, and then the green arsenical pigment dusted on from a kind of flour-box. The dust is scattered, and may be breathed in, or may pass into the body by the

mouth and stomach. The avoidance of the evils are treated of at p. 79. It is to be noted that the use of these dangerous pigments is happily being gradually abandoned in this trade, and some harmless vegetable colouring matter substituted. (See also pp. 34 and 93.)

Arsenic in the Textile Trades. — In certain dyeing processes arsenical pigments are used, and may occasionally cause poisoning. To describe one or two of these is sufficient; the others are all similar.

The dangers of the textile industries have already been discussed under the headings of "Dusty Occupations," p. 22, and of "Lead Poisoning," p. 54, which should be consulted.

Arseniate of soda is employed for dyeing cloth Turkey-red. It is used to fix the alumina mordant in Turkey-red dyeing by means of alizarine. The cloth is treated with the alumina salts, then dried, and fixed by passing through a solution of arseniate of soda in water, contained in a tank. It is then washed, but it is not handled in these manipulations. It is next dyed with the alizarine. In yarn dyeing the process is slightly different. It is necessary to handle the yarn to turn the hanks whilst they hang in the solution. In this particular branch (yarn dyeing) the solution is so dilute that little danger is run during the dyeing process. But it must be remembered that the use of arseniate of soda requires the greatest care. It can readily be seen how easy it is for the poison to be conveyed to the body during its use, either from immersion of the hands in the solution, if it be at all strong, and entry through cracks and abrasions of the skin, or by contaminating the hands and conveying to the food or mouth, and so on.

The remarks on prevention, already made at p. 79, need no amplification.

Fellmongers.—The wool is removed from the hides by means of lime, which is often mixed with orpiment, or sulphide of arsenic. It is used to preserve skins during transit, and is also contained in the mixture employed in treating badger and other skins.

(See article on "Fellmongering," at p. 157.)

The channels of entry are clear—the dust of arsenic used for preservation purposes may be shaken out of the skins as they are moved about, and this may be breathed in. It may get on to the hands from this same source, and so contaminate food; and it may find entry to the body also during the unhairing process by the same means.

The prevention, and so on, is fully described at p. 79.

Printers who use green pigments (Scheele's and Schweinfurt's green) or yellow pigment (orpiment), and painters who grind these pigments and use them, are liable in the same way to inhale the dust and get it into the stomach by means of contaminated food.

In *lithographing*, green arsenical pigments are used. The colour is dusted on to the paper, the pattern of which has been previously stamped in size, and the excess is afterwards shaken off. It can easily be seen how the dust may be inhaled, or the poison conveyed to the stomach.

The remarks on the mode of entry, and its prevention, at p. 79, need not be repeated. (See also p. 102.)

Manufacture of Arsenical Pigments.—The chief arsenical pigments employed are Schweinfurt's green (emerald green), Scheele's green, and orpiment. These pigments are insoluble in water, but are partially dissolved in the juices of the stomach.

Schweinfurt's green is an aceto-arsenite of copper, and is prepared in a variety of ways; but in all of them verdigris and white arsenic are the essential materials. Usually the verdigris is dissolved in acetic acid, and added to a boiling aqueous solution of white arsenic. After the boiling has gone on for some time, emerald green is deposited. This is dried and packed. It is during these operations, the drying and packing, that the dust is scattered and inhaled, and gives rise to the poisoning symptoms described at p. 79.

Scheele's green is prepared by dissolving in separate portions of hot water white arsenic and blue vitriol—the solutions are mixed, and to the mixture is added a solution of potassium carbonate.

Orpiment is obtained by passing a stream of sulphuretted hydrogen gas through an acid solution of the oxide of arsenic, the yellow orpiment being precipitated.

It is again during the drying, crushing, and packing of the pigments that danger arises. For prevention see p. 79.

The Tinting and Staining of Wall and other Papers.—For green and buff colours arsenic was at one time very largely employed. Vegetable colours have in this as in many other trades happily to a large extent abolished their use, and therefore the evils arising from them.

Reference must also be made to the article on "Dusty Trades" in connection with this subject, at p. 34, where the manufacture of wall-papers, and so on, is fully treated of.

In tinting various kinds of paper, *e.g.* fancy papers, wall-papers, and so on, the pigment is generally used in a moist state, and very often diluted. The pigment is mixed with warm size and water, and spread by a brush. The roll of paper passes between rollers, and through a shallow pan of the material, and then under brushes to spread it evenly.

The paper comes out with the colour distributed uniformly, and is hung up in strips to dry. The rolling up of the strips detaches a good deal of dry arsenic containing dust. During the spreading operations not much dust is scattered, but still arsenic can get splashed on to the hands and clothes of the workers, and so gain entry to the body by the usual channels (see p. 79).

The chief item in prevention is to use vegetable colours instead of arsenical; but if employers should continue to use the obnoxious and dangerous pigments containing arsenic, the advice given above at p. 79 is applicable here. Machinery should be used to carry the strips to the drying room.

Bronzers.—Some of the bronzing powders used in various trades contain arsenic, and those who employ them are liable to be poisoned by it. The channels of entry and preventative measures to be adopted are those already fully discussed at p. 79. (See also article on "Bronzing," p. 100.)

Arsenic is also used in a large number of other occupations in a lesser degree—in making shot, in enamel making, in glass making, in the manufacture of red lacquer, by furriers and by felt-hat makers, and so on.

Nothing need be added to what has already been said; it will be plain how in these various employments the arsenic may enter the body, and all that is needed in the way of prevention is given at p. 79.

Chronic Mercurial Poisoning.

This variety of metallic poisoning is not nearly so frequent as those already described, chiefly because the number of workers employed is comparatively small. It arises in those

who work in metallic mercury (quicksilver) or its salts. The trades and occupations in which it most commonly occurs are—

Workers in quicksilver mines.
Workers in gold and silver mines.
Makers of barometers, etc.
Makers of mirrors.
Vermilion manufacturers.
Furriers.
Photographers.
Bronzers.
Silverers and gilders.
Hat makers.
Telegraphists.
Artificial flower makers.

The poison enters the body by three channels—by the lungs, by the digestive system, and by the skin.

1. By the lungs. The vapour of the metal which is given off at even low temperatures, or the dust of the metal or its salts, may be breathed into the lungs.

2. By the digestive system. Particles of mercury and its compounds may be swallowed, and permit of the entrance of the poison in this way.

3. By the skin. The metal itself is absorbed through the unbroken skin with facility, and this would be especially easy if the hands were in constant contact with it.

The onset of the disease must be recognised, so that treatment may be adopted at an early stage. The chief symptom of mercurial poisoning is the tremulous movement of the limbs and body, known as "mercurial tremors," or "the trembles." This may be accompanied by inflammation or ulceration of the mouth and gums, very offensive breath, a copious flow of saliva, and a metallic taste in the mouth.

Then fever, restlessness, stomach troubles, and finally, in bad attacks, delirium and mania may occur.

The precautions to be adopted to stop the onset of this disease are not elaborate and difficult. They are well worth taking, for they may prevent a very serious or even fatal illness. It is an undoubted fact that a large risk is run by those who work in this metal, and this risk can be very much lessened by adopting the precautions enumerated below. The reason that cases of poisoning do not more frequently occur is simply due to the fact that the number of those occupied in the various trades in which mercury is employed is small. In the ten years ending in 1892, 59 deaths occurred from mercurial poisoning—40 males and 19 females. Of these, 34 (16 males and 18 females) were suicides, so that only 25 cases of death from industrial mercurialism happened in ten years.

It must be remembered that metallic mercury is volatile at all temperatures, therefore from the surface of any open vessel containing mercury vapour arises, whether the place in which it happens to be is hot or cold—of course to a larger extent the warmer the room is; therefore any vessel containing mercury should not be left exposed to the air, but should be kept covered. Care also should be taken not to spill any of the metal about the place, and the floors should be so constructed that any that is spilled can easily be collected, and none left about to volatilise. They should be made of some substance like asphalte, and kept moistened, so that the mercury shows itself more easily. If the floor is slightly slanted, and provided with gutters, the collection of escaped mercury is made more easy. Tinfoil, which forms an amalgam with mercury very readily, should be kept about the floor, or other parts of the room where the metal is likely to be spilled. This is not only a good sanitary precaution, but is

also economical, for the amalgam can be utilised for the recovery of the mercury.

A practice commonly employed is, during the times at which rooms and workshops in which mercury is employed are not being used, to allow the vapour of ammonia to pass freely through them. Why this should be of use one cannot say, for metallic mercury does not combine with ammonia, but as a matter of experience it has been found useful.

At work the men should wear overalls fitting tightly at the wrists and neck, to prevent any particles getting on to the clothes and body. The hair, beard, and nails should all be kept short, and a paper cap should be worn on the head. The object of all these precautions is to prevent the dust and vapour of mercury from being deposited on the various parts of the body.

The greatest cleanliness should be observed. Hot baths, especially sulphur baths, should be taken frequently; the hands should be vigorously scrubbed with hot water and soap and a hard nail-brush before any food is taken, so that, by these means, the risk of poisoning the food by hands dirty with mercury or its salts may be avoided. The mouth should be well rinsed frequently, so that any little fractions of mercury which have got in may be washed away and not swallowed. Chlorinated water is a very good preparation with which to do this. The teeth also should be well and frequently brushed.

Working clothes should not be worn when away from work.

The rooms should be frequently cleaned to free them from the dust and dirt of mercury, and also well ventilated to get rid of mercurial fumes, etc. The vapour is very heavy, and therefore the ventilation should be downwards. All cloths and such things should be put away as soon as possible, for

if they contain mercury this may volatilise, and allow the vapour to diffuse about the room.

Ordinary respirators, or even those described at p. 4, are not of much use: the vapour passes readily through the meshes. But respirators provided with a sponge wrung out of a weak solution of silver nitrate, or dusted over with sulphur, are of benefit. They act chemically upon the vapour, converting it into a less harmful substance, and thus diminish the risk of poisoning.

A dose of sulphur internally, taken occasionally, is of advantage. As those who are under-fed and intemperate are much more liable to be attacked than the well-fed and temperate, care should be taken respecting these two last points.

Once signs of the entry of the metal into the body arise, a medical man should be immediately consulted. Amateur treatment is a waste of very valuable time.

A few words must be added, dealing with each particular trade in which there is the chance of this poisoning arising.

Workers in Quicksilver Mines.—Mercury is found in nature, sometimes in the native state, but more commonly as cinnabar (the sulphide of mercury), or the subchloride (calomel). It is the only metal which is liquid at the temperature of the air, and is so volatile that it gives off vapour at all temperatures, high and low. The metal is chiefly obtained from its native salt, cinnabar, by mixing it with slaked lime or iron filings, and distilling in retorts, for the purpose of getting rid of the sulphur. Sulphide of iron or lime is formed, the mercury being converted into vapour, and condensed in receivers filled with water.

The remarks on mercurial poisoning in general and its prevention, given above, should be attended to: all that

specially needs remark is, that care should be taken that the apparatus is well constructed, so that no fumes may escape and be inhaled.

Workers in Gold and Silver Mines.—These men use a large amount of mercury amalgam in their work, in the process of extracting the precious metals from their ores. It may enter the body by the usual channels, described under "Mercurial Poisoning in General." Nothing special, beyond what has already been said as to prevention, calls for remark here. (See pp. 85 to 89.)

Makers of Barometers, Thermometers, and various other Philosophical Instruments.—Mercury, which has to be raised to a high temperature, escapes, and the vapour is disseminated, and may be inhaled. The poison, too, may enter the body by the skin, from constant handling of the metal. The paragraphs on poisoning by mercury, given above, should be consulted. No special remarks regarding prevention are called for. (See pp. 85 to 89.)

Mirror Makers.—At the present time, owing to the almost universal adoption of the new process, whereby a thin film of metallic silver is deposited on the glass, the danger of mercurial poisoning is almost abolished in this trade, but at one time the silvering of mirrors was a dangerous process. The metal was simply rubbed on to the glass to silver it, the hands being frequently immersed in the metal; if this process is ever carried out now, the metal should only be rubbed on by means of a cloth, held as far away from the face as possible. Nitrate of mercury is sometimes used instead of the metal. This substance is put on the glass by means of a glass rod. But danger attaches to this compound,

though not to the same extent as in the use of the metal itself. The best way of entirely avoiding any risk of mercurial poisoning in this trade is to adopt that process whereby a thin film of metallic silver is deposited on the surface of the glass, no mercury being used at all. If mercury or its salts should be employed, the section on mercurial poisoning and its prevention apply here. (See pp. 85 to 89.)

Vermilion Makers. — This may be made by simply grinding selected pieces of cinnabar to a fine powder. During this operation it is easy to see how easily, if done in open vessels, the dust might escape into the atmosphere and be ready for attacking the workmen. Closed vessels should be used in grinding, and ventilation by means of fans and shafts provided in the room. The remarks on mercurial poisoning in general and its prevention should also be consulted. (See p. 87.)

Vermilion is sometimes made artificially in various ways, one of which is here described. Mercury and sulphur are well mixed and agitated in drum heads till they have combined. The powder is then sublimed in vertical iron cylinders surmounted by heads, which are connected with receivers. On heating properly, the vermilion condenses in the retorts. This is ground, and then properly cleaned. The remarks made above concerning the grinding of the powder, etc., apply equally here.

Furriers. — Arsenical soaps and corrosive sublimate (perchloride of mercury) are used for preserving and stuffing skins: the skins are brushed on the hairy side with a solution of nitrate of mercury, arsenic, and perchloride of mercury— they are then dried and brushed by machinery, cut and

sorted. The danger of getting these substances into the system exists both during their actual use and afterwards, when the materials have become quite dry and dust of the metals is scattered all over the rooms. Nothing beyond what has already been said on poisoning by mercury and its prevention at p. 85 need be added. (See also "Arsenical Poisoning," p. 85, and "Anthrax," p. 147.)

Photographers.—The biniodide of mercury is used largely by photographers. Their hands are constantly touching it, and food is easily contaminated with it if it should be partaken of with unwashed hands, with the result that the symptoms of poisoning follow. The remarks on prevention, made above, apply here. (See p. 87.)

Bronzers.—Workers in this process employ an amalgam of mercury, tin, and bismuth, which is used for bronzing over plaster figures, etc. This amalgam is rubbed over, and then varnished. During the rubbing process it may enter by the skin, and vapour may be given off and inhaled. No special remarks on prevention are required; those made above apply here. (See also article on "Bronzing," p. 100.)

Gilders.—Mercury and gold, in the form of an amalgam, are employed in the process of gilding. The surface is first cleaned, and then washed with a solution of the acid nitrate of mercury, and after this the amalgam of gold and mercury is spread over it. Heat is applied to drive off the mercury, and the surface is finally burnished by rubbing with some hard stone. The constant handling of the amalgam allows the introduction of the poison through the skin. During the preparation of the amalgam in the bath, vapour in plenty is given off and inhaled by the workman: so volatile is the

metal that at the time of application of the amalgam, and especially when the mercury is driven off by heat, fumes are given off and breathed. It may be mentioned, *en passant*, that the nitrous fumes evolved during the process are also highly injurious.

Electroplating has to a large extent replaced this method, but not entirely. This would, of course, abolish the risk of poisoning with mercury; but when the old process is adopted, the precautions enumerated under "Mercury Poisoning in General" should all be carefully carried out. Enclosed glazed boxes and cupboards, in which the hands are introduced for the requisite manipulations, should be employed, and this would almost prevent the risk of any fumes entering the lungs, but of course would not affect the entry of the poison by means of the skin.

Hat Makers.—The skins are often prepared by brushing them with a 10 per cent. solution of acid nitrate of mercury; afterwards, when the skins are shaken, mercury dust is scattered about and inhaled. The preventative measures are those detailed above, under "Mercury Poisoning in General." (See also article on "Felt-hat Making," p. 159.)

Telegraphists.—In telegraph offices the connection of the wires is often made by little cups filled with mercury. These cups are quite open, and the telegraphists inhale the vapour of mercury with the result that poisoning follows. The only way to avoid this is not to use mercury connections.

Artificial Flower Makers.—Workers in this trade use arsenical and mercurial pigments. The salts of mercury employed are the biniodide (bright scarlet), the sulphide

(vermilion), and the chromate. The dust of these is readily scattered, and enters the body by the usual channels. The remarks on mercurial poisoning and its prevention, made above, here apply. (See also sections on "Dust Diseases," p. 34, and "Arsenical Poisoning," p. 81.)

Sole-stitching by the Blake Sole-stitching Machine.—This is an occupation which is reputed to be accompanied with the risks of mercurial poisoning. It is therefore necessary to say a few words upon it.

A description of the ingenious machinery is unnecessary—all that is required for our purpose is to state that the whole of the "horn" of the machine is at a high temperature, and that, for the purpose of preventing the escape of gas used in working the machine, cups of mercury are necessary.

It has been supposed that the temperature to which the mercury was exposed caused its volatilisation, and its subsequent inhalation and evil consequences. But a careful investigation by the Departmental Committee appointed by Sir Matthew White Ridley, shows clearly that the risk, if any, is infinitesimal.

Chronic Copper Poisoning.

This is not a very common or a very important industrial disease; for, firstly, the number of workers employed is small, and secondly, the metal is not a very poisonous one. But still there are certain classes of workers who are liable to it, and we must therefore devote a small space to the matter.

The occupations in which it may arise are as follows:—

Clock Makers.

Braziers.

Turners, filers, and polishers of copper.

Those engaged in cleaning and repairing old copper boiler tubes or vessels.

The mode of entry of the poison into the body is practically the same as in the case of lead, *i.e.* either by swallowing it into the stomach, or by inhaling the fumes into the lungs.

The symptoms of the disease are as follows: a pale colour of parts naturally a red or pink colour, such as the lips and cheeks, the gums and inner surface of the eyelids: pain in the stomach, and vomiting; a green line on the gums, and a greenish colour of the hair, together with great prostration.

Very little need be said on the subject of prevention. The rooms and workshops should be well ventilated, and revolving fans and shafts fixed to machinery where dust is created, to carry away this dust. Personal cleanliness in this as in all other metallic trades is essential. No food should be eaten in the workrooms; the hands should be diligently scrubbed with hot water, soap, and nail-brushes before taking food; the use of the bath and the tooth-brush must not be forgotten. Overalls, fitting tightly at the neck and wrists, should be worn, and the hair, nails, and beard kept short, so that no particles may be harboured by the body and clothes of the workers. Respirators of the pattern described on p. 4 should be used in dusty occupations, *e.g.* polishing, to catch any particles and prevent them reaching the lungs.

Once symptoms have arisen, a medical practitioner should be consulted.

Poisoning by means of Zinc.

This is even more uncommon than copper poisoning, but the affection is liable to occur in those who are occupied in extracting the metal from its ores, in those occupied in grinding the oxide, in those who use galvanised wire for wiring bottles, and in coopers who use zinced iron hoops.

The mode of entry is mainly by the inhalation of the vapour or the dust of zinc or its oxide. It may also be introduced into the body by means of the mouth and stomach—for instance by contaminating food from eating with dirty hands after handling the oxide.

The symptoms produced are: cough, stomach trouble, paleness, and a dirty grey skin, with blindness at night. After a long time there is very slowly developed a kind of paralysis, and tremulous movements of the body.

To avoid these risks, practically the same precautions should be adopted as in the case of lead poisoning. The rooms should be well and properly ventilated, to remove as much as possible of the vapour and dust; and great personal cleanliness is essential. Hot baths should be taken as often as possible; the hair, beard, and nails must be kept short, to prevent any harbouring of the dust in them; overalls, fitting tightly at the neck and wrists, to prevent the dust getting to the clothes and body, should be worn; the hands, after finishing work, must be well scrubbed with soap and hot water and a hard nail-brush before any food is taken, so that no risks of getting the metal on to the food may be run; and no food should be eaten in a workroom. Respirators may also be worn, if much dust happens to be flying about, to hinder the access of the particles to the lungs. These precautions will almost do away with any risk of poisoning.

In extracting the metal from its ores, the chief of which

are calamine or carbonate of zinc, blende or sulphide of zinc, and a red oxide, the ore is first crushed and afterwards roasted. This roasted ore is mixed with anthracite, and afterwards deoxidised by the process of distillation downwards. During this operation the vapour of zinc and its oxide are thrown off, and the poison passes into the system by the inhalation of the dust or vapour of the metal.

The remarks made above on prevention are all that are necessary.

The Manufacture and Use of Zinc Oxide.—Zinc white, or Chinese white (oxide of zinc), is used as a white paint, in calico printing, and in the manufacture of artificial meerschaum pipes. It is made by heating pure zinc to the distilling point, when it burns into the white oxide. Vapour is given off, and may be inhaled during this operation. The oxide must afterwards be ground to a fine powder, and at this time fine zinc white dust is scattered in the air and breathed in. It was hoped, considering how much less poisonous it is than carbonate of lead, that it might have replaced the latter as a white pigment. But practical experience has shown that it will not stand the wear and tear of outdoor exposure so well as lead. The remarks on prevention already made apply here.

Those who handle Zinc Wire, used for wiring bottles, and coopers who use zinced iron hoops, may occasionally, from constant contact of the hands with the substance, be poisoned. This is quite uncommon, and nothing beyond what has already been said on prevention is needed.

Makers of Galvanised Iron do not suffer from zinc poisoning, but they are liable to be attacked with chronic dryness

and irritation of the nose, and ulcers inside the nose, from the fumes of the chloride of zinc.

The manufacture of galvanised iron articles, such as wire, pails, baths, sheets, etc., is thus conducted:—The bucket, or whatever it is, is first well cleaned by immersion in a bath of weak hydrochloric acid. During this manipulation unpleasant and irritating fumes arise.

The article is now ready for galvanising. This is done in a large tank of molten zinc, which is prevented from becoming oxidised by throwing in sal-ammoniac, at once giving rise to thick fumes, which are irritating and unpleasant. The symptoms caused by the vapours are mainly lung symptoms—difficulty of breathing, cough, expectoration and fever, cramp in the limbs and trembling.

The article is finished by dipping it for a short time into the melted zinc, and then into cold water.

The precautions to be adopted to prevent the onset of these symptoms are simple—cowls connected with rotating fans should be fixed to both the tanks used for cleaning and to the vats containing the melted zinc. These carry away the fumes, but the very greatest care is needed to see that the fans are kept in working order, for the acid fumes are very liable to corrode them.

No meals must be taken in the workrooms.

If symptoms should arise, a medical man should be at once consulted.

Poisoning by Chromium.

This is not one of the important industrial metallic poisonings, but occasionally it arises in those who use chromium salts for various dyeing and colouring purposes—brown, black, yellow, orange, red, and green being the chief colours produced by it.

The trades in which we find examples of this affection are—

- Calico dyers.
- Calico printers.
- Dyers of silk, linen, and wool.
- Painters on glass and porcelain.
- Makers of coloured papers for bonbons.
- Bichromate of potash manufacturers.

The chief sources of all chromium compounds is chrome ironstone. This must first be powdered and sifted, during which a large amount of dust is necessarily given off. The reader is referred to p. 1 for the results and prevention of this evil.

Green oxide of chromium (chrome green) is thus manufactured:—Mercurous chromate is heated in a retort until all the mercury is driven off, leaving the oxide; or else by heating and then calcining potassium chromate and ammonium chloride, washing the mass with hot water, drying, and again igniting.

The emerald oxide of chromium is made by mixing and then calcining boracic acid and potassium bichromate. The mass is treated with cold water, washed, ground wet, washed again, and dried.

Chrome yellow is made by boiling white lead with bichromate of potash in water.

Chrome red is produced by the action of caustic potash on the yellow salt.

Bichromate of potash is prepared from the neutral chromate in a state of solution by adding nitric acid. The bichromate is deposited.

The making, grinding, and use of all these various salts may be followed by the signs of poisoning by chromium—the channel of entry being either through the lungs or the stomach. The dust scattered about in the various manipula-

tions of grinding and so on are breathed into the lungs, or particles may contaminate the hands and so be conveyed to the food.

The symptoms are as follows: there is discharge from the nose, ulceration and perforation of the division between the nostrils, skin eruption, and sometimes bronchitis and fever.

The methods for avoiding the dangers run by these workers are as follows:—The salts when pulverised for any purpose should be reduced to the state of powder by machinery in closed chambers, and not by pestles in open mortars. Those who are in any way compelled to handle the powders should adopt the most stringent precautions as to cleanliness. The hands should be well and vigorously scrubbed in hot water with soap and a nail-brush, after work is finished, and before any food is eaten. Hot baths should be taken once or twice a week. The tooth-brush must be frequently used. The hair, beard, and nails should be kept short, and overalls fitting tightly at the neck and wrists worn, so that no chrome dust may be harboured on the body or get to the clothes. The mouth should be well rinsed before food, to wash away any chromium that has accumulated, and to prevent it being swallowed. No food should be eaten in the workrooms. These should be well ventilated (see Chap. VI).

In the operations where much dust is created respirators should be worn (see p. 4).

On the onset of any symptoms suggestive of poisoning, a medical man should be consulted immediately.

BRONZING.

This is a process, used in a variety of trades, for the purpose of producing the appearance of bronze on articles

which are not real bronze. The latter substance is an alloy of copper and tin, with a little zinc and lead.

Bronze powders are of various colours—for example, gold, silver, red, or green. They consist of different substances, mainly metals in a state of powder, the best of them in a very fine state of division indeed. A kind of powder often employed consists of copper and tin, with a small proportion of arsenic. If a silver colour is wanted, powdered tin with a little antimony is used.

Whatever the trade in which these bronzing powders are employed, the risks are very much the same, namely, those due to metallic poisonings of various kinds, *e.g.* arsenical, mercurial, and lead, and those due to the inhalation of very fine dust in considerable quantities.

In the bronzing of common goods, such as plaster and wooden figures, the article is first covered with glue or varnish, and then the powder, consisting usually of copper with a little arsenic, dusted on.

Here it is easy to see how the fine dust is scattered about. It covers the hair, clothes, and skin of the workers, or it may be licked by the lips, and so get to the stomach.

The dangers which may arise are the production of skin eruptions and ulcers on the skin, the onset of lung trouble, just in the same manner as in other dust inhalation (see p. 1), and the development of arsenical and mercurial poisoning (see pp. 85 and 92).

These articles are also sometimes bronzed by means of an amalgam of mercury, tin, and bismuth. This amalgam is rubbed over the figures, and they are then varnished. Mercurial poisoning may arise during this process—it may enter through the skin whilst being rubbed in, or vapour may be given off and inhaled.

The reader is referred to the article on "Mercurial Poisoning," pp. 85 and 92.

In bronzing metallic objects, copper mixed with some other substance is deposited on the surface, the composition of the mixture varying according to the colour required. If black and green bronze is wanted, the article is immersed in a solution of sulphuric acid and sal-ammoniac, or in arsenic and sulphur. The articles require a preliminary cleaning by immersion in some acid solution—here again the vapour of acids escape. The risks of this branch of the trade arise from the inhalation of acid fumes, which cause coughing and bronchial trouble, together with indigestion, stomach pain, and diarrhœa or constipation.

The only way to avoid the dangers from these fumes is to well ventilate the workroom, so that the vapour is carried away and not breathed in.

The risks of arsenical poisoning are also run by these workers; the reader is referred to p. 78 on this subject.

Bronzing in Lithographic Printing Works.—This is required for the manufacture of show cards, Christmas cards, wedding and funeral cards, illuminated texts, and so on. The powders employed are of the composition mentioned above, viz. a mixture of copper and zinc with a little arsenic, or a powder of tin with a little antimony.

It may be carried out either by hand or machine. If by hand, the pattern is first stamped in size on the sheet or card by machinery, and whilst still wet the bronze powder is gently rubbed on by means of a soft pad of cotton wool or chamois leather. During the manipulations of the pads the fine dust is scattered all about, and the hair, clothes, and skin are rapidly covered with the minute particles.

The excess of dust on the cards must now be removed.

The "dusting off" process once more raises large quantities of dust into the surrounding atmosphere.

If the machine process is adopted, the one most usually employed consists of a number of rollers and brushes, which revolve and bring the proper quantity of powder to the card, or whatever it may be, which has already received its pattern in sizes, and is still wet. The machine is covered in, and so to a large extent retards the escape of dust. But it must be noticed that there is always some escape from it, and also from the cards, etc., which have always a superfluity of dust on them, which must be brushed off. This brushing off may again be done by hand or by machinery.

The dangers of this occupation are those caused by the inhalation of abnormal amounts of dust, and those caused by metallic poisoning.

The articles on these subjects at pp. 1 and 83 should be consulted. The following few special remarks may be made:— Respirators should most certainly be used by the employés. Overalls, of a light colour to show the dust, should be worn, and kept clean by frequent washing—at least once a week; head coverings, to prevent the dust accumulating in the hair, are advisable. Cleanliness is of extreme importance—the hands should be scrubbed with soap and hot water before eating, and the meals should not be taken in the workroom. The hair, nails, and beard must be kept short, to stop dust accumulating on them. The use of hot baths and the employment frequently of the tooth-brush must not be forgotten. All machinery should be covered in when possible, and the rooms properly ventilated.

A drink of half a pint of milk, twice a day, should be provided. This is found useful; but how, is a matter of speculation and conjecture only.

The machine process is better than the hand one; less

risks are run in it. If the hand method is employed, the patent pad invented by Ruddock is advisable. In this the powder for bronzing is put into a tin reservoir, which has a soft padding round the bottom, covered with chamois leather. A small valve, moved by a spring at the top, when pressed by the worker, liberates a uniform amount of bronze. This diminishes the amount of dust flying about, and consequently the dangers of the work.

POISONING BY BRASS.

Brass Founder's Ague.—This occurs in those who work in brass, which is an alloy of zinc and copper. The occupations in which it arises are—

Brass founders.
Brass casters.
Brass turners.
Brass filers.
Brass polishers.

The channel of entry of the poison into the body is mainly through the lungs, by the inhalation of vapour or of minute particles of brass. But it may enter also through the stomach, by being swallowed.

The symptoms of brass founder's ague are the following:—The mouth and throat are dry, the voice is husky, and asthmatical attacks occur. There are feelings of chilliness, sweating, or shivering fits, headache, nausea or vomiting, with great languor and depression. The existence of these symptoms, or anything like them, should at once lead the worker to suspect he is being poisoned by brass.

The prevention of the onset of this disease differs rather according to the kind of brass work that is being done, but

in all of them thorough and efficient ventilation is important, to render the air as pure and free from particles and vapour as possible. Great personal cleanliness, such as scrubbing the hands before meals with soap and hot water and a hard nail-brush, so as to get rid of all brass contaminating the hands and therefore likely to render the food poisonous, wearing overalls fitting tightly at the neck and wrists to prevent the dust getting on to the body and clothes, frequent hot baths, and avoidance of eating meals in the workroom, are all very important. Dust should as far as possible be carried away by shafts and revolving fans, and respirators worn when many solid particles are flying about. (See "Respirators," p. 4.)

The intemperate are much more likely to be attacked than the temperate; steady habits are therefore of great importance.

Brass Founders.—Those engaged in mixing the copper and zinc suffer most. The copper is first melted, and then the zinc and a little tin and lead added. As they mix, violent chemical reaction takes place, and fumes of zinc oxide mixed with those of copper are given off. This vapour is breathed in, and causes brass founder's ague. The men generally cover their mouths with cloths, but a much better plan would be to use the simple respirator described at p. 5. The rooms should be large and well ventilated, so that the fumes may not be too concentrated, and the precautions described above adopted.

Those occupied in re-melting the brass pigs also suffer, and the remarks just made as to mixers do not require any addition.

Brass Turning and Filing.—Here a good deal of brass dust is raised, which may enter the body by means of the lungs or

stomach, and, to avoid this, shafts with rotating fans should be provided, to draw away the dust as it is formed and before it contaminates the air. See also precautions on brass poisoning in general, given above.

Brass Polishing.—The fashioned articles are polished by friction on rotating wheels; emery or some other polishing powder is used, so that the dust created is not pure brass, but brass mixed with emery or some such substance. Here again the use of rotating fans and shafts to suck away the dust is the chief method of prevention. The paragraphs on brass poisoning in general must also be referred to.

In *lacquering and dipping*, brass poisoning does not arise, but as they are the finishing processes for brass goods they will be described here. Dipping simply consists in immersing the article, whatever it may be, *e.g.* a candlestick, fireiron, or inkstand, in a weak solution of sulphuric or hydrochloric acid, then dipping it in water, and finally in a solution of soda.

The acid fumes give rise to pain in the stomach, with diarrhœa or vomiting, cough and asthma. All that can be done to prevent this is to well ventilate the workrooms, for the methods of doing which see the section on "Ventilation."

Lacquering is the brushing on of the lacquer—a solution of shellac and spirits of wine—whilst the brass is hot. Fumes again arise, and cause headache, dizziness, loss of appetite, and cough. Again, the preventative measures consist in the adoption of an efficient and proper system of ventilation, to the chapter on which the reader is referred.

CHAPTER III.

CERTAIN CHEMICAL TRADES.

Alkali Manufacture—Chloride of Lime—Hydrochloric Acid—Sulphuric Acid—Iodine—Bromine—Aniline—Nitro and Di-nitro Benzole—Explosives (Roburite, Tonite, Melanite, etc.).

ALKALI MANUFACTURE.

THE manufacture of alkali from salt is not at the present time such an important industry as it was in former years, owing to the introduction of what is known as the ammonia-soda process.

The main technical procedures for the production of alkali are as follows:—Common salt is placed in a furnace, sulphuric acid added to it, and heat is applied—hydrochloric acid gas is given off, and "salt cake" (sulphate of soda) is left behind. This salt cake is placed together with some chalk in huge revolving furnaces, and, after being subjected to the action of a high temperature, the mass remaining, called "black ash," is wheeled in trucks to tanks of water in which the soda is dissolved. The liquor is afterwards boiled down, and soda ash obtained. During the operation, fumes of hydrochloric acid gas, of carbonic acid gas, and of sulphurous acid gas are generated. If caustic soda be required, the alkaline liquor is boiled down to the required density, drawn off, and rapidly assumes the solid state. Here, during the boiling, steam containing particles of caustic soda rises,

which injures the skin of those on whom it settles. From the waste heap of alkali works sulphuretted hydrogen gas, sometimes mixed with sulphurous acid gas, is given off, and contaminates the surrounding atmosphere. They are both poisonous, especially the former.

The dangers which arise in this chemical industry are mainly due to the inhalation of the fumes of various gases—hydrochloric acid gas, carbonic acid gas, sulphurous acid gas, and sulphuretted hydrogen gas. The local action of the particles of caustic soda on the skin must not be forgotten.

The inhalation of these gaseous fumes gives rise to various disorders in those exposed to them, especially lung trouble, such as bronchitis, asthma, and pneumonia. Different individuals vary very much in their susceptibility, some being rapidly attacked, and some hardly suffering even after a considerable time.

Very little, unfortunately, can be said in the matter of preventing these evil effects. The substitution of the ammonia-soda process, which is a more economical one, would do away with them—otherwise all that can be done is to see that all the workrooms are thoroughly and efficiently ventilated, so that the fumes may be carried away to the outside air before they reach the lungs of the workpeople. (See article on "Ventilation," Chap. VI.)

The irritation of the skin caused by the fine particles of caustic soda settling on it is not serious, if it be not allowed to progress. Attention should be paid to it as soon as it is detected.

A medical man should be consulted if any symptoms of lung trouble should be discovered.

If the fumes of sulphuretted hydrogen give rise to unconsciousness in a worker, he should be at once removed from the poisonous atmosphere, and artificial respiration at

once resorted to (see p. 166). A medical man should at the same time be summoned.

The Manufacture of Chloride of Lime.

This is a very important substance, used largely in bleaching works for cotton and linen, bone and ivory goods, and for sanitary purposes of various kinds.

To make it, it is necessary to first produce hydrochloric acid: the method of manufacture of this compound is described on p. 111. The hydrochloric acid is mixed with oxide of manganese in stone stills—chlorine gas is set free and conveyed to a chamber where lime, previously slaked and sifted, has been spread out to a depth of a few inches on the floor. In the course of a few days the chlorine is absorbed, and chloride of lime is produced. Very often the substance is put into casks in the chamber itself—frequently, too, before time has been given to the chlorine to be properly absorbed.

The dangers of this manufacture are considerable. During the slaking and spreading of the lime the dust is scattered around, and may cause irritation and inflammation of the skin or eyes, wherever it happens to settle; or it may be inhaled, and set up bronchitis and destruction of the lungs, with cough, spitting of phlegm, and considerable difficulty of breathing.

To avoid or lessen these risks, the exposed parts of the body should be smeared with oil, and care should be taken not to wash off any lime with water, as this would cause severe burning of the skin. Rooms should be ventilated as far as is practicable (see Chap. VI.), and respirators worn, to catch the dust of lime, and prevent it reaching and destroying the lungs (see p. 4).

The removal of the bleaching powder and the packing into casks are still more harmful. The usual practice is for the men to cover the head with woollen cloths, wear eye protectors, and fasten folds of brown paper round their legs. They then go into the chambers, are hardly able to breathe, both from the irrespirable nature of the gas and from the way they cover their mouth and nose, and they come out in a very short time in a state of semi-suffocation. As a result of continual exposure to the vapour they get sneezing and coughing, hoarseness of voice, inflammation of and bleeding from the lungs.

It is not an easy thing to entirely avoid these great risks, but in the first place no workman should be permitted to go into the chambers at too early a stage—plenty of time should have been allowed for as much as possible of the chlorine to be absorbed. The men should not, as they often do on account of their work being piece-work, strain every effort to remain as long as possible in the room; for the state of half-suffocation into which they get is a very bad thing for them, especially when frequently repeated. The process of cask filling should not be carried out in the chambers in which the stuff is made. The chloride of lime should be shovelled down a shoot, the end of the shoot and the mouth of the cask being covered by a coarse cloth to prevent the escape of dust, etc. The chambers into which the chlorine gas passes should be made carefully, so that there are no holes or cracks through which the gas can escape into the surrounding atmosphere and be a source of danger to the workers near.

Dr. Arlidge suggests that a good plan would be to have those employed inside the chambers provided with a light helmet, very like a diver's helmet, made of some material not acted on by chlorine, such as guttapercha or some thin

metal, and into which a supply of fresh air could be pumped. Some protective covering should also be used for the body.

Exhaust fans have been recommended, but these probably would draw away too much chlorine from the chloride of lime.

The wearing by those exposed to the fumes of chlorine of a sponge respirator moistened with an alcoholic solution of ammonia, which combines with the chlorine, is a good plan.

The inhalation of aniline has been recommended, but this is a bad plan. It may temporarily relieve symptoms, but it leads to the formation of chloraniline, which is a very dangerous product.

THE MANUFACTURE OF HYDROCHLORIC ACID.

There are a large number of ways in which this substance can be made, the one usually employed being known as the Leblanc process.

This is a method whereby common salt (chloride of sodium) is decomposed by sulphuric acid, the resulting products being hydrochloric acid and sodium sulphate. The salt is put into furnaces and sulphuric acid added to it, and heat then applied to the furnaces. The hydrochloric acid gas is carried by pipes to a high tower, filled with coke, over which a stream of water runs. By this means the gas is condensed, and the liquid acid falls to the bottom of the tower. The furnaces require to be watched and heated till all the hydrochloric gas is given off.

The dangers of these operations are those due to the escape and inhalation of acid fumes.

The risks arise both whilst the salt and sulphuric acid are being heated, and also during the removal of the salt cake from the furnaces. This is generally done whilst the

cake is still hot, and, as there is still some gas adhering to the cake, the removal of it in barrows in this hot state is attended with the escape of injurious fumes.

The symptoms caused are cough and irritation of the bronchi, indigestion, pain and diarrhœa, or constipation.

The avoidance of the troubles is best managed by the proper ventilation of all the rooms and factories (see Chap. VI.), and also by taking care that time is allowed for the salt cake to cool, after it is raked out of the furnace and before it is wheeled away. No fumes will escape from the cold cake.

When any illness has arisen, a medical man should be at once consulted.

The Manufacture of Sulphuric Acid.

Of the large number of acids made and used in this country, sulphuric acid is undoubtedly far the most important. It is employed in the production of most of the other acids, and it is largely used in various arts and manufactures. In South Lancashire alone 160,000 tons are made every year.

The process is as follows:—Sulphur dioxide is made, either by burning sulphur in a current of air, or by roasting a mineral called iron pyrites—a compound of iron and sulphur—in a proper furnace. A small stove containing nitre is placed in the central part of the furnace, where this salt is decomposed by sulphuric acid being poured upon it. Nitrous fumes are generated. The mixed gases, *i.e.* sulphur dioxide, nitrous fumes and air, are conducted to large chambers, made of sheets of lead, supported on wooden beams and uprights, often of a cubic capacity of 500,000 feet. Jets of steam are blown into the chamber at various points from a boiler, and a thorough draught is maintained.

Eventually the sulphuric acid falls on the floors, and is drawn off. To get the pure acid, this weak acid must have the water driven off by evaporation, first in lead pans, and finally in glass vessels.

The dangers which may arise in this manufacture, apart from the caustic and burning action of the acid itself, which will not be treated of here, are those due to the inhalation of fumes and gases of an irritating and poisonous nature.

In the production of the various gases no danger arises, unless there is some fault in the construction of the oven and the gases escape.

In the cleaning of the chambers, which is a very necessary procedure, if they are entered before all the sulphurous acid has escaped, the vapours are inhaled, and give rise to the symptoms enumerated below. To cleanse the chambers, they are entered by workmen who spread a layer of sawdust all over the floor. Some time after they remove this, together with any deposit of sulphate of lead that may have formed. The disturbance of the deposit sets free poisonous gas mixed with it, and thus causes the production of more fumes.

The symptoms are as follows:—There is irritation of the throat and lungs, with hard, dry cough. There is an acid taste in the mouth, loss of appetite, irregularity of the bowels, and general failure of health.

To obviate the dangers, care should be taken that the doors are opened some time and water injected before the workmen enter. When they do enter they should wear some covering over the mouth, and have specially high and strong boots, to protect their legs from being burnt.

It would be advantageous to place in the chambers, before they are entered by the workmen, some absorbent medium, such as vessels of water, of milk, of lime, or of

warm sawdust: these substances absorb the poisonous gases, and so prevent them injuring anyone. Or some oxidising agent, such as manganese dioxide, or lead dioxide, may be distributed about; this oxidises the sulphurous acid, and so does away with its harmful effects.

Every now and then the poisoning is acute; the workman inhales the fumes so rapidly that he becomes unconscious very quickly—his breathing fails, his heart-beats become weak, and his countenance livid. This does not often happen, for the fumes are so irritating that one can generally at once escape from them if they are too strong.

If this should occur, remove the individual into the fresh air, perform artificial respiration, as described at p. 166, and send immediately for medical aid.

The Manufacture of Iodine.

Dried seaweed is gathered into heaps and burnt, and the ash, known as kelp, which contains iodine, is heated with sulphuric acid and manganese dioxide, and afterwards sublimed: during the various stages of this manufacture the vapour of iodine escapes.

This when inhaled causes irritation of the mucous membrane of the breathing tract, with sneezing, watering of the eyes, running of the nose, headache, sometimes even insensibility. The skin gets inflamed from constant handling of the material.

The avoidance of these injurious results is best attained by keeping the vessels employed quite air-tight, so that the iodine is condensed and cooled and no irritating fumes escape.

In removing the iodine from the vessels, it must be remembered that, as the vapour is given off at the ordinary

temperature of the atmosphere, symptoms may arise, unless care be taken not to breathe the fumes.

Attention must be paid to the skin. If it becomes inflamed, means must be taken to cure it at an early stage.

Manufacture of Bromine.

This is found in nature in the form of bromides in mineral springs and seaweed, etc. The mother liquor obtained by evaporation, or by treating the ash of seaweed (kelp), is distilled with sulphuric acid and manganese dioxide in stone vessels, and finally purified by fractional distillation.

It is a dark brown heavy liquid, with an irritating strong smell. It is kept in bottles with well-fitting stoppers fixed with clay to hinder evaporation, which takes place constantly when the liquid is exposed to the air. The symptoms produced by the inhalation of this vapour are cough, spasm in the throat, and suffocation.

The chief danger of breathing the fumes occurs when the stone vessels are being emptied and when the bottles are being filled—in short, during any manipulations in which the bromine is being poured from one vessel to another, or during which the workman is brought near any exposed bromine.

The only way to avoid the serious risks involved by breathing this vapour is to carry out a thorough system of ventilation to remove the fumes as soon as formed, and to wear some form of respirator to make it more difficult for them to reach the lungs. Only strong healthy men should be employed; no one with lung disease and no intemperate workers must be engaged, for they are much more liable to be attacked.

If at any time a worker should be overcome by suffocation with the fumes, remove him at once to the fresh

air, get him to inhale some steam if possible, or, if he is too far gone to do this, perform artificial respiration at once (see p. 166). Send for medical aid.

MANUFACTURE OF ANILINE.

This is derived from the tar of gas works by distillation. Benzine is first produced; this is converted into nitro-benzine, and then into aniline.

The fumes of aniline, of nitro-benzole, of nitrous and sulphurous acids, and of mirbane, all arise and contaminate the atmosphere, are inhaled, and produce the symptoms of a narcotic poison, convulsions, loss of power, loss of feeling, and insensibility. This must be treated by removal of the individual from the presence of the noxious fumes, and the performance of artificial respiration: for the method of carrying out this, see p. 166.

The workers, besides this acute form of poisoning, are liable to a chronic poisoning, as evidenced by headache, giddiness, cramp, sleepiness, and so on.

The only way of avoiding these dangers is to have the apparatus constructed as well as it possibly can be, in order to avoid fumes escaping; and to have the rooms so ventilated, by means of fans and shafts, etc., that the fumes might be carried off as soon as formed (see Chap. VI.).

THE MANUFACTURE AND USES OF NITRO AND DI-NITRO BENZOLE.

Nitro-benzole is made by the action of strong nitric and sulphuric acids on benzole; di-nitro benzole, by further treating at a higher temperature than that used for the nitro-benzole.

Nitro-benzole is a light yellow liquid, known as artificial oil of bitter almonds, or essence of mirbane. It is used to make aniline, and as a scent for soap and perfumery, and as a flavouring for confectionery.

Di-nitro benzole consists of yellow-tinted prisms, soluble in alcohol and ether. It enters largely into the composition of various explosives, such as roburite, a large quantity of it being employed in their manufacture (see p. 118).

These bodies may enter the system by inhalation, by ingestion, or by absorption through the skin, the former being the most serious.

The symptoms produced are headache, giddiness, difficulty in walking, difficulty in breathing, sleepiness, insensibility, and finally death.

The means to be adopted to prevent the onset of poisonous symptoms are as follows:—All workrooms must be well ventilated, and kept at a low temperature (a low temperature always coincides with a low sick-rate). The workpeople must be very robust; they should take plenty of nourishing food, and should avoid the use of alcohol, or, at any rate, of all but the smallest quantity. Personal cleanliness, washing the hands well with soap and hot water and a hard nail-brush, the use of overalls fitting tightly at the neck and wrists to prevent the poison getting to the clothes and skin, and frequent warm baths, must all be attended to.

Milk should be taken during work-time, and the hours should be short. No food should be kept, or meals taken, in the workroom.

If any nitro-benzole should have got into the stomach, the individual should be made sick at once—a tablespoonful of mustard in a tumbler of warm water, or the same quantity of salt in warm water, will generally effect this; or a wine-glassful of ipecacuanha wine, or twenty grains of sulphate of

zinc, may be administered if the above-mentioned are not efficacious. Tickling the back of the throat with a feather or the finger will almost always answer, if all the preceding should fail. No oil, fat, or alcohol of any kind should be given, for the poison is soluble in these substances, and therefore is rendered more easily absorbed from the stomach. Medical aid should be at once sent for.

Explosives: Manufacture and Uses.

In this connection the preceding section on nitro-benzine must be read.

There are now a very large number of workers employed in the manufacture of various explosives—in 1895 over 10,000. In that year there were 152 accidents, causing 40 deaths, and injuring 167 people.

The chief compounds made are roburite, dynamite, nitro-glycerine, tonite, melinite, and gunpowder.

Di-nitro benzole is very largely used in the manufacture of these explosives. It is thus employed:—The di-nitro benzine, which reaches the factory in lumps in a pure state in casks, is ground in a machine like a mortar. The yellow powder is then removed to the mixing shed, where it is mixed with the proper substances, varying with the explosives required. It is next taken to the cartridge shed, where the cartridges are filled; these are subsequently dipped into a mixture of liquid wax and paraffin, to render them waterproof.

During the grinding and mixing the workers are exposed to the risk of inhaling both the fumes and the pulverised dust, and to contamination of the hands, which may, unless care is taken, be conveyed to the mouth. The cartridge makers also suffer from handling the stuff. The channels of

entry, then, are the lungs, the mouth, and absorption by the skin.

The symptoms are those of poisoning by di-nitro benzine, just described (p. 117)—chiefly difficulty of breathing, loss of sight, unsteadiness of gait, and a bluish coloration of the skin.

As to the avoidance of these dangers, all that has been said regarding dusty occupations, at pp. 3 to 6, applies. The workrooms must be well ventilated, and rotating fans should be employed to carry away the dust and vapour. Great cleanliness is essential—no food should be taken till the hands have been very thoroughly washed and scrubbed with soap, hot water, and a hard nail-brush. No meals must be taken, and no food kept in the rooms. Overalls, to prevent the dust getting to the body and clothes, must be worn; they should fit tightly at the neck and wrists. Respirators, to catch the dust, should be employed.

If any should be swallowed, the treatment is that just given in the section on nitro-benzine.

Use of Explosives.—Miners are those who mostly employ these, and who especially suffer from the fumes.

Roburite is a mixture of one part of chlorinated di-nitro benzine and seven parts of nitrate of ammonium. The gases and fumes arising from its explosion are carbonic acid, nitrogen, and hydrochloric acid.

Tonite is a mixture of equal parts of gun cotton and barium nitrate. Nitrogen, oxygen, water, and barium carbonate are produced by its explosion.

Gunpowder is a mixture of charcoal, sulphur, and nitre. The gases arising from its ignition are carbonic acid, carbon monoxide, sulphuretted hydrogen, and nitrogen.

The fumes of these various gases are mostly very

injurious — they cause headache, sickness, giddiness, and difficulty in breathing. The fumes are mostly invisible, and therefore are more readily inhaled.

The avoidance of these dangers is best attained by firing the explosives by electricity at some distance off, so that no workman is near the fumes when they are produced—by proper ventilation of the mine or space where the explosion takes place—and by waiting at least five minutes before going near the place of explosion.

If a workman should be overcome by the fumes, have him at once removed from the neighbourhood, commence artificial respiration, and send for medical aid (see p. 166).

Picric acid: melinite. Picric acid is made by pouring nitric acid on carbolic acid. It is used for the production of melinite. It gives rise to much the same symptoms as those already described under nitro-benzine. Its ways of entrance into the body and its prevention are also similar.

CHAPTER IV.

SOME MISCELLANEOUS OCCUPATIONS.

Trades in which Rapidly Revolving Wheels are used—The Manufacture of Aërated Waters—Working in Compressed Air—Electrical Works—Manufacture of Matches—Wool-Sorter's Disease and Anthrax—Tin Plate Workers—Oil Cloth, Floor Cloth, and Linoleum Makers—Leather Making and Fellmongering — Felt-hat Making — Glass Making—Eye Accidents—Artificial Respiration.

TRADES INVOLVING THE USE OF RAPIDLY ROTATING WHEELS (GRINDSTONES AND EMERY WHEELS).

IT is especially in those trades known as the Sheffield trades that these revolving stones are used, but in various other occupations, *e.g.* glass polishing, much the same process is carried on. As examples, one or two of the more usual uses of these wheels may be described, but all that is said here applies equally to the use of rotating stones for any other purpose.

Grindstones: all steel tools and articles such as scythes, needles, saws, fish hooks, sword blades, razors, forks, scissors, etc., after leaving the forge in the rough state, must be at some time or other during their production subject to the process of grinding. This grinding is done on a grindstone, revolving on a spindle, worked by means of a belt, and the speed at which it is necessary that the stones should revolve, often up to 1500 turns per minute, is the cause of the frequent breaking or flying of these wheels, and the projection

forward of the pieces of stone at a great velocity, and with terrific force.

Emery wheels are used for much the same purpose and in much the same way as grindstones, but the rate of revolution, as the wheels are usually much smaller, is higher, sometimes up to 7400 revolutions per minute.

The dangers common to these occupations are the following: first and foremost, the inhalation of dust; secondly, accidents to the eye from the particles of stone and steel scattered broadcast by the wheels; thirdly, the breaking of the rapidly revolving stones and the consequent forcible hurling outwards of the fragments; and fourthly, the risk of onset of sciatica, etc., from the constrained position necessary for the work, and from the constant dampness and moisture which envelops the operatives during the wet grinding process.

The first industrial risk referred to has been already fully discussed in the article on "Dusty Occupations," in which it was pointed out that the danger of the onset of various diseases of the lungs was very great in those exposed to the continual inhalation of large quantities of dust. This dust, of course, is produced in much larger quantities during dry than during wet grinding, and as far as possible the former process should always be carried out. But unfortunately this is impossible in the case of such small articles as, for instance, needles. Ventilation, fans to suck away the dust produced, and the wearing of respirators are the means to be employed to prevent the onset of lung affections. (Refer to the article on "Dusty Occupations," p. 1.)

Accidents to the eyes are fully treated of at p. 163.

The breaking of the stones is a matter well worth consideration, for annually a large number of lives are sacrificed by preventable mishaps. In two years, according

to Her Majesty's Inspector, 31 men were killed or injured by the breaking of grindstones. Probably many more accidents were not reported, and all these might have been saved with a little care.

The stones may break from some inherent fault in the stone itself, from the high rate of speed at which they are run, or from carelessness in using and storing them.

(*a*) The inherent faults of the stone itself may be due to the fact that there is a flaw in it, or it may be too soft, or it may arise from some damage done to the stone during the blasting operations at the quarry. The risks from faulty stones would be avoided by having them run in a machine at a higher rate of speed than that at which they would travel when actually in use, the testing machine being so constructed and covered that in the event of an accident the pieces could do no harm. This testing operation will always, or nearly always, detect the fracture, etc., in a faulty stone in the course of ten to fifteen minutes.

(*b*) The high rate of speed at which stones are run is another source of danger. The pulley, which should be about half the diameter of the stone, may be too small, and consequently the wheels revolve at a more rapid rate, or the machine may run away, which of course increases the rotation rate.

(*c*) Carelessness in using or storing gives rise to the production of a "heavy side," which, when the stone revolves, causes fracture. A stone used for wet grinding may be left partly immersed in water, which is absorbed, and thus this part of the stone becomes heavier; or this heaviness may be produced by allowing a stone which has been used in water to remain for some days at rest when out of water. All the fluid gravitates to one place, and produces a "heavy side." This defect, too, may be due to storing carelessly, say in a

pool, or exposed to rain and wet. Frost, after exposure of the stone to rain, will cause a fracture; and in Sheffield it is a common event for many accidents to happen after a frost.

The means to be adopted to prevent these dangers are quite obvious after the preceding remarks. Effective measures must be taken to ensure the soundness of the stone by avoiding explosives in quarrying, by proper storing, and above all by a preliminary testing. Care also should be taken in the running and the fixing of the stones. They should not be allowed to rest for more than a few, say ten hours in water, and wet stones should not rest more than one day in the same position. Whilst running, they should be so placed that as far as possible no risks would be run by the workers, even if they should break.

The constrained position, sitting bent across a "horse" for hours together, combined with the damp, moist atmosphere of wet grinding, gives rise to a good deal of sciatica and lumbago in the workers. The only remedy that can be suggested for this is to avoid as far as possible the unhealthy position. This is also one more argument in favour of substituting dry for wet grinding wherever practicable.

THE MANUFACTURE OF AËRATED WATERS—THE TESTING OF BOTTLES BY COMPRESSED AIR.

There is only one important danger connected with these two trades—the breaking of bottles, in the first-named by the pressure of the carbonic acid gas, in the second by the pressure of the compressed air.

The processes by which aërated water bottles are filled and corked are numerous, and the machines employed are

very various, but there is no necessity to describe these: the danger common to all is the bursting of the bottles by the high pressure (often 200 lbs. to the square inch) of the gas or compressed air, and the consequent danger of cuts and various other injuries to the workpeople.

After ordinary bottles are made, they are sometimes tested to see if they are sufficiently strong and perfect, and to discover any flaws or defects. It is a very good system, for it prevents bad bottles being used for filling with aërated waters, and thus diminishes the danger to the fillers of these bottles.

To avoid the risks of injury to hands, face, etc., from the flying pieces of glass, the employés, whether engaged in filling, wiring, labelling, or examining the bottles, should wear face guards or masks, and full-length gauntlets coming right down to the finger joints: the guards often worn, coming only down to the wrists, are *not* sufficient; they leave a very important part, the hands, exposed to injury. Those engaged in wiring perhaps cannot wear the full-length gauntlet on the right hand, as it interferes with the manipulations of the wire, but they should certainly wear the full-length glove on the left hand, and the shorter on the right. On the side of the employer, the precautions to be taken are also important: the bottling machines should be of such a character that in the case of the bottles bursting, the fragments would be prevented by screens of wire gauze from reaching the operator.

Although it is now the general if not the universal custom to provide these masks, etc., for the workers, it is unfortunately by no means the usual rule for them to be worn. The employés prefer running the risk of injury to the slight inconvenience caused by the wearing of the masks and gloves, and the consequence is that cuts and wounds

of all parts of the body are very frequent in the fillers, etc., of the bottles.

There is just one piece of advice in connection with these cuts from broken glass that may be given: it is well that they should be seen and attended to by a competent surgeon at once, otherwise they may take very much longer to heal, and besides are much more likely to be followed by serious results, leading even to lockjaw or blood poisoning in some of its forms.

Of the minor dangers in mineral water factories little need be said. There is always a good deal of waste water running about, so that the floors are generally in a bad condition. To escape the bad results of constantly working on a wet floor, a raised wooden grating should be provided for the workpeople to stand on, and the floors should be drained in order to keep them as dry as possible.

The risk of poisoning by carbonic acid gas, used in aërating the waters, is now, owing to the way in which it is made, non-existent: in former times, before the improved method of manufacture had been discovered, it was by no means an unknown thing.

Working in Compressed Air in Caissons.

Those occupied in bridge and tunnel building where caissons or coffer dams—large iron tubes sunk deep in the bed of a river—are used, are subject to the evil effects of compressed air. These occur also to a less extent in those who use the diving bell.

The caisson, according to M. Foley, is an enormous iron tube, which is sunk in successive sections, bolted together, and ultimately filled with concrete. On the surface is a mechanical construction consisting of three chambers, the

central one circular, in direct communication with the shaft which is being sunk. On either side is a chamber shut off from it by an iron door accurately fitted, but capable of being opened as required. One lateral chamber is intended for the entrance of the workmen, the other for their exit. The door of the former gives admission from without, the one within it communicates with the central chamber and shaft. The individual on entering closes the outer door behind him, and then opens an aperture through which the compressed air rapidly flows, and when the pressure in the two spaces is about equalised he passes into the central division, closing the intervening door. After the same fashion, in reverse order, he retreats from the exit chamber, having first permitted the entrance of the outer air into it.

The high pressure exists in the central chamber and throughout the length of the working shaft, at the bottom of which men are employed in excavating and sending up the soil from the bed of the river. The degree of pressure varies from a fraction of an atmosphere to three or even four atmospheres.

Those who are exposed to this compressed air are liable to various symptoms on removal from it. They suffer in proportion to the degree of pressure, to the duration of exposure, and to the rapidity with which the ordinary atmospheric pressure is restored.

Some of the common symptoms are enumerated: pain in the legs and trunk, pain in the stomach, with nausea and vomiting, headache, giddiness, paralysis, insensibility, and sometimes even sudden death.

These symptoms are generally worse in those new to the work: habit seems to lessen them. Different individuals, too, when all the conditions are identical, suffer in different fashion.

To avoid these symptoms arising, the change from high

to low pressure must not be too sudden. The workman after entering the exit chamber must not let in the outside air too quickly. At least five minutes should be allowed for each atmosphere of extra pressure. Thus, if the air in the caisson is at three atmospheres, fifteen minutes must be given; if at four atmospheres, twenty minutes; and so on.

The caisson should not be entered fasting; a meal should always have been taken a little while before. The excessive use of alcohol also makes the symptoms much worse, so stimulants must only be taken by the workers in great moderation.

If symptoms threaten, the workman should at once go back to the increased pressure. But as access to the caisson is not a matter that can be quickly carried out, there should be a chamber at hand in which a patient can be placed and into which compressed air can be quickly admitted. The compressed air can then very slowly be allowed to escape. By this means the symptoms are usually at once relieved, and do not return, as the pressure is gradually diminished.

As severe exertion after leaving the increased pressure is injurious if there is an ascent by stairs, the lock should never be placed at the *bottom* of the shaft. It should always be at the *top*, so that the exertion of climbing may be performed in the compressed air.

The Generation and Distribution of Electricity: Electrical Shock.

Electricity is now very largely used in a great number of industries and for a great number of purposes. It is employed in telegraphy, in telephony, in various chemical operations and manufacturing processes, for producing motive power for launches, machines, and motor cars, but it is

especially made use of for lighting streets and large buildings by arc lamps, and houses by incandescent lamps.

Of the many ways in which it can be produced, the only one that need concern us is the generation of electricity by dynamos at the central station and its distribution to the various houses, lamps, etc., by cable mains. There are three different systems of supplying electricity—the direct or low pressure system, the transformer or high pressure system, and the accumulator system.

In the direct or low pressure system the electricity is supplied at a low tension direct to the lamps of the consumer, the whole of it passing to the places served; and in order that the resistance of so large a current may not be too great, large cables, which mean a large quantity of copper, must be used. The electro-motive force does not exceed 100 volts, and so danger is avoided, the strength of the current not being sufficient to do harm.

The transformer, or high pressure system, supplies electricity at a high tension, usually about 2500 volts, which is reduced to safe limits, 50 to 100 volts, in the consumer's house by a transformer. This is simply a modified induction coil, used for the purpose of transforming a high pressure small current into a low pressure large current. In this method, which is the one that mainly concerns us, the current is produced by dynamos at the central station, and conducted by two mains along the walls. The size of the cable, and therefore the amount of copper, is much less than in the low pressure system. At each house a transformer is placed, and there the primary circuit in the cable, at a pressure of say 2500 volts, is converted in the secondary circuit (the wires in the house) to a current at a pressure of 50 to 100 volts. The Board of Trade orders that the strength of the current in the consumer's house shall not exceed 200 volts. In practice

it is rarely more than 100 volts. It will be seen, then, that the danger of shock from high tension or strong currents occurs only in the primary circuit,—the dynamos, the switch-boards, the cables, and the transformers, etc.,—and not in the secondary circuit in the house.

The accumulator system may be either high or low tension. The former, the high pressure system, consists in placing the accumulators at the consumer's house, charging them with a high tension current from the central station, and discharging them at a low pressure on to the consumer's wires. In the latter, the low pressure system, accumulators are placed at the central station, the accumulators supplying the current when the supply required is small, and the dynamos charging the accumulators and helping to supply the mains when the demand for electricity is large.

It is necessary to describe the various parts referred to in some detail, before proceeding to the subject of electrical shock.

The dynamo is an apparatus which, by the combustion of some kind of fuel, such as gas, oil (benzoline or petroleum), or coal, converts mechanical into electrical energy. These machines necessarily vary according to the current required, but in all cases they consist of two parts, the electro-magnet and the armature, one fixed and one moving, and this motion produces currents in the armature, the currents being either direct, *i.e.* flowing constantly in one direction, or alternating, *i.e.* flowing first in one and then in the reverse direction, changing at about the rate of 50 to 200 times a second. If the field magnet revolves, the armature remaining still, the current (which is of necessity alternating) may be conducted away directly by cables fixed to the terminals of the armature. In the most usual type of machine the electro-magnet is the stationary portion, and this is of a horseshoe shape, the

armature revolving between its two ends. It is obvious that the current cannot be led away directly from the armature, but must be conveyed by some other method: this is managed by fixing to the armature conducting rings if an alternating current is required, or commutator strips (made of bars of copper insulated with mica) if a direct current is required. As the armature revolves, sliding friction is made between these and a fixed collector or brush, and thus the current passes to the cables.

By means of a switchboard the engineer is enabled to so arrange the connections of the cables, dynamos, fuses, and measuring instruments that the current can be conveyed in any required direction. This apparatus consists simply of a board or slate with all the switches and instruments collected together.

The cables are composed of strands of copper wire, numbering 3, 7, 19, 37, or 61, insulated by either gutta-percha, indiarubber, or some fibrous substance, such as jute, hemp, or cotton, saturated with waxes, resins, or oils. Of all these, vulcanised indiarubber is by far the best.

The transformer consists of a core of iron, which has wound round it two independent coils of wire, one having a high, the other a low resistance. There is no metallic connection between the two. The ends of the low resistance coil are connected with the main going to the house, the ends of the high resistance coil are connected with the primary mains—it is, in fact, an ordinary induction coil. It is, as has been stated, for the purpose of converting a small current at high pressure into a large current at low pressure. According to the proportion of the two sets of wires on the core of iron, the consumer's current can be caused to have any desired relation to the main current.

The arc lamp consists essentially of two carbon rods

separated by a small gap. When the current is turned on, the rods are by a mechanical device separated a little way, the current still passing between them. The mechanism must draw the rods apart so as to start the arc, and also keep them the proper distance away as they are gradually consumed.

Dangers of the Process of Generating and Distributing Electricity.—The dangers which belong to machinery in motion are not peculiar to this occupation, and will not be considered here. Lead poisoning may occur in those who make and handle the plates for storage batteries (see "Lead Poisoning," p. 44). In the use of accumulators there is the possibility of the generation of explosive mixtures of gases which may take fire in the presence of a light. Proper ventilation will obviate this danger. The risk of the occupation, *par excellence*, is that of electrical shock. This is a grave danger, almost inherent in those occupied in the work of generating and distributing high pressure currents. All that is necessary for its production is that two parts of the body should touch conducting materials differing in pressure by 1000 volts or more, even supposing the contact is not very perfect, and of much less difference in pressure supposing the contact is perfect: under these conditions, an electrical shock passes through the body, which may give rise to very severe, possibly fatal results. Now, most materials are conductors of electricity—the earth, especially damp earth, wires, metals of all kinds, water, etc. etc., are all conductors—in fact, the workman, if in doubt, should consider everything a conductor; so that anyone standing on the ground and touching a body charged at a dangerous pressure will receive a severe shock. If he should be standing on some non-conducting material, such as glass or rubber, then no effect would be produced, for only one part of the body is handling a conductor; but if he

should at the same time touch two bodies at a pressure differing from one another by about 1000 volts, then, even though he be standing on non-conducting material, a severe shock will be received. In the occupation we are considering, the things which are at high pressure, and which are liable to be touched, are the high pressure cables, the transformers, the switchboard and its metallic connection, the dynamos, and, in the case of a series of arc lamps, the lamps themselves.

The cables: the high pressure mains are nearly always laid underground, and are always insulated, by means of a rubber or some such covering. This will prevent a workman touching it from receiving a shock, but a slight injury to the rubber or other insulating material may allow of such a shock as to produce death immediately.

Transformers are dangerous when there is any deficiency in the insulation of the high pressure wire. If the high pressure cable from some accident becomes non-insulated, and thus a high pressure current is passed on to the casing, the strong current will melt the fuse and put the faulty part out of circuit. If no highly charged metal is exposed, nothing can be touched which will give rise to a shock.

The switchboard has at the back all the ends of the cable and the conductors from the dynamos, connected with their proper metal blocks. This part should not be capable of being reached by any but those who thoroughly understand the working of the machines. On the front, where most of the ordinary work is done, there should be no metal employed directly connected with high pressure currents. The risk, then, is confined to touching the various parts at the back of the board.

Dynamos — those producing alternate currents: when the magnet revolves and the armature is fixed, the cable terminals are the only parts with high pressure currents

liable to be touched, and these are easily cased in. With the reverse kind of dynamo, when the magnet is fixed and the armature revolves, there are the terminals of the armature, the contact rings, and the terminals of the machine connected with these by two brushes. Any touching of these parts, the brushes or contact rings, causes a severe shock. Dynamos producing direct currents: here the parts liable to be touched and give rise to shocks are the commutator strips and the brushes.

The symptoms of electrical shock are as follows:—The muscles are thrown into a state of such contraction that they cannot let go their hold; severe and deep burns are caused; the man may be stunned, or even immediately killed, without signs of any injury, either by cessation of the breathing, or else by sudden stoppage of the heart.

It will be of interest and of great practical importance to study rather fully some of the fatal accidents which have occurred of late years from electric shock. Sixteen accidents are recorded below. The pressure in volts of fourteen of these averages 2500; the lowest was 1000 volts; the majority of them were about 2000 volts. Five of these were in connection with transformers, so that, notwithstanding the fact which has been pointed out, of the ease with which it is possible to avoid danger at this part of the circuit, a large proportion of the accidents occurred here. In one of these cases, the deceased was going down an iron ladder, and put one foot on the transformer, which had become highly charged, owing to the fact that the earth connection from the transformer casing was insufficient, and the main cable imperfectly insulated. In another, the man lifted the fuse box from the top of the transformer, for the purpose of examining the terminals, thus breaking the earth connection of the transformer casing: defective insulation of the high

pressure main was again at fault. In a third, a man dusted a high pressure fuse board without the glove on one hand: the mistakes were the wearing of only one glove, the fact that the work was done without the current being switched off, the floor was damp and of cement, and the fuse terminals were unprotected. In a fourth, in a chamber where the high pressure terminals were unprotected, the worker's elbow came in contact with one of the terminals. In the fifth, a man attempting to assist another man suffering from severe but not fatal shock was killed: the causes being his failure to wear gloves, the defective aërial cables, and the fact that the high pressure cable was imperfectly protected. Of three cases occurring in connection with switchboards, the first was caused by touching both exposed terminals while manipulating a switch, the connecting metal strips being so placed as to be most liable to be touched by the fingers of the hands, if the handle provided failed. In the second, the deceased went up a ladder, and came in contact with some high pressure metal usually out of reach. In the third, the man was making alterations when he accidentally touched bodies charged at different pressures: there was want of space at the back of the switchboard, and the exposure at one time without protection of metal parts charged at different pressures was a mistake. Of the cases occurring in connection with a dynamo,—in the first, whilst regulating the speed of an engine, the deceased grasped an insufficiently protected wire, which was highly charged. In the second, a man was oiling the bearings of an alternator machine, the bed of which was earthed. It is supposed a short circuit was set up by the oil-can, which was made without an insulating handle: the guard rails fencing the machine also were not made of insulating material. Of the other cases, two happened in the distributing stations of the extra high

pressure system: one man, while in charge of the station, attempted to remove another from contact with a charged omnibus bar; he was killed, through the omnibus bar not being discharged or fenced: the second, a workman unused to the work, was binding a cable to a terminal with wire close to a highly charged omnibus bar when he received a fatal shock. This was due to the employment of an unskilled workman upon highly dangerous work: the space was too confined, and the omnibus bar was not discharged. The other cases were: one of a man employed on centrifugal pumps in a factory; deceased was arranging an iron ladder, which became entangled in the connections of an arc lamp: another was the case of a man who failed to use the gloves which were provided when pulling back the slack of an insulated live main cable. The last two were those of two men, one of whom was cleaning an electric street lamp when he received a shock which killed him, leaving him suspended from the wires; the other tried to remove him, and was killed by touching the dead body. It will be noticed that in three of these cases the deceased man was attempting to assist someone who had met with an accident. It must be remembered that, whilst a dead or injured man retains his hold of the wire, etc., it is dangerous to touch him or his clothes.

For the purpose of avoiding accidents from electric shoek, the following recommendations were issued in 1897 by the Departmental Committee appointed by Sir Matthew White Ridley to investigate this matter. They are intended to apply only to high pressure stations, or to any part where there is a direct current of 700 volts or more, or an alternating current of 350 volts or more.

1. The frames and bed plates of all generating machines shall be efficiently connected to earth.

2. The rails, fencing, dynamos, or other generating machines shall be made of wood, or other non-conducting material.

3. All terminals, collecting brushes, main connectors, parts of dynamos, motors, or other appliances to which neither Regulation No. 6 nor No. 7 applies, shall be so placed, covered, or fenced with non-conducting materials that no person can touch accidentally, either with his body, clothing, or any conducting tool, two parts differing from each other by an amount which constitutes a high pressure. This rule is to be read in connection with No. 4.

4. The floors of all places where it would be possible to make connection with metal at high pressure shall be covered with an insulating mat of suitable material, and kept in a state of efficient insulation.

5. The material used for wiping or cleaning the commutator strips or collector rings of dynamos, motors, or rotary converters of any form, shall be applied by means of an insulating handle.

6. In switch rooms, and on the front of switchboards, the main switches, main fuses, main terminals, omnibus bars, and all other metallic parts, shall be insulated or arranged in such manner as to render it impossible for any person by accident or inadvertence to touch them.

7. The backs of all switchboards shall be kept closed, except for the purpose of alterations or repairs. When such work has to be carried on, either at the back or at the front of switchboards, the following regulations shall apply:— (*a*) No person except a skilled electrician, or a workman under his personal and immediate supervision, shall be employed when any part is at high pressure. (*b*) No extensive or serious repairs shall be executed on metal which is at high pressure. (*c*) Where the alterations or repairs are not of an

extensive or serious character all metallic parts at high pressure shall be covered with an insulating cap, or protected by some form of insulating covering, only one part, or several at the same pressure, to be exposed at any one time.

8. All switchboards erected after the application of these rules shall have at the back a clear space of at least four feet. This space shall not be used as a store room or lumber room, or obstructed in any manner.

9. Any person at work upon a cable or portion of the mains under high pressure shall wear indiarubber gloves on both hands.

10. All aërial high pressure conductors in factories or workshops shall either be insulated over their entire length and supported at such frequent intervals that in the event of breakage they shall not come within reach of places where persons are liable to pass or to be employed, or shall be so placed and arranged as to comply with the requirements relating to such wires in streets enjoined by the Board of Trade.

11. The gloves shall be supplied by the occupier, and it shall be the duty of the manager to see that they are in a proper state of repair, and are worn by the workpeople.

12. No examinations, repairs, or alterations necessitating the handling of mains, wires, machines, or other apparatus, shall be carried on, except in cases of urgent necessity, while such parts are under high pressure, and all such work shall be done under the personal supervision of an electrical engineer or competent manager or foreman.

13. Where operations are being conducted upon mains from which the current has been cut off, the switch shall be locked, and precautions taken that it shall not be unlocked except by the person in charge of the station, on his being satisfied that the danger is at an end.

14. Every vessel used for lubricating purposes shall be so constructed that it cannot act as a conductor between the hand and anything touched.

15. Metal transformer boxes shall be efficiently connected to earth, and so constructed that in the event of "running to frame" the earth connection will not be broken by the removal of the fuse box, or any other part of the box.

16. Transformer cases, iron ladders, and all permanent metallic parts contained within the transformer chamber, and not forming part of the electric circuit, shall be metallically connected together.

17. All holes in transformer cases, through which high pressure conductors pass, shall be lined with suitable and effective non-conducting material.

18. All high pressure connections within a transformer chamber shall be so protected with insulating material that it shall be impossible to touch them.

19. Switches which can be conveniently operated from the outside for cutting off both the high and low pressure connections of the transformers shall be fitted in all transformer chambers erected after the application of these rules, and in all existing chambers, unless it is proved to the satisfaction of Her Majesty's Chief Inspector of Factories that such an arrangement would be attended by special difficulty.

20. Every post or support where series arc lighting is employed shall be provided with means for completely disconnecting the arc lamps from the mains without disturbing the action of the other lamps.

21. All persons engaged in electrical works shall be made fully aware of the dangerous parts of the machinery, cables, and their connections, and shall be practically instructed in

methods of artificial respiration: that known as Sylvester's is both simple and efficacious. Rules for artificial respiration, and for the restoration of persons apparently killed, or injured, shall at all times be kept affixed in the station. All persons engaged in the works shall thoroughly understand these rules and be capable of putting them into practice. In the event of a person being rendered unconscious by an electrical shock, artificial respiration shall, on the careful removal of the body from its electrical contact, be at once resorted to, and a qualified medical man immediately summoned.

22. All accidents occurring in generating stations or transformer chambers shall be notified according to the provisions of Section 18 of the Factory & Workshop Act 1895.

The treatment of a man who has been rendered insensible and apparently dead by a powerful electric shock has been noticed in No. 21 of the above rules. It must be remembered that death in many cases of electrical shock is only apparent, and that animation may be restored if efforts at resuscitation are not too long delayed. The one method of treatment to be adopted is the performance of artificial respiration: this should be resorted to at once, while waiting for the arrival of the medical man, and continued till breathing recommences. Even if there is no sign of this recommencement for some time, artificial respiration should still be kept up for at least an hour, for restoration has happened even when the heart has apparently ceased to beat for some little while. It is therefore desirable that every workman employed in the work should know how to perform this properly (see "Artificial Respiration," p. 166). Care must be taken not to touch with the naked hand the injured individual if he retains his hold of the body charged with electricity. Rubber gloves should

be worn, or if not at hand a thick layer of dry cloth of some sort should be used to grasp the victim.

Note.—Since writing the above I have collected several more cases of death from industrial electric shock. One of these was that of a workman in Bradford, and in this case the voltage was only 225. He was standing in damp boots, on earth into which there had been a leakage, and he touched with his perspiring hands an electric lamp. Death was instantaneous. This is an important case, for it shows how low a voltage may occasionally cause death.

Another case happened in Southampton. Leakage was suspected in a low tension cable lying side by side with a high tension cable. Although the operative was a skilled workman, he touched the high tension cable without gloves, with the result that he was instantly killed. At the inquest it was urged that the turning off of the current would have been attended with very great inconvenience to the consumers, and that "live" high tension cables could, if great care was exercised, be repaired. This was an example of studying the convenience of the consumers at the cost of a workman's life: the 9th and 12th regulations mentioned above would have prevented this death.

At Ashton, a man touched a handle on a switchboard, the pressure of which was 500 volts: he was immediately struck dead. This is another instance of death from a comparatively low pressure current.

Manufacture of Matches.

This is an industry very largely carried on in Sweden and Germany, but also in this country to a considerable extent, about 2500 workers being employed in it.

The principles of manufacture are the same, except for

safety matches, whatever the variety of match required, whether it be lucifers, wax vestas, fusees, or vesuvians: the details differ, but it is only necessary to describe the production of one of them in full—the ordinary wooden match.

The wood is cut up into stems of the required size, and these pieces are fixed into frames, some thousands in each, in such a manner that the ends are all level, preliminary to dipping, in the better-class matches, or made up into bundles for the commoner matches. The wooden pieces are then slightly charred at the end upon which the composition is to be placed. They are dipped to the required level in the composition, which consists of white phosphorus, chlorate of potash and glue, together with powdered glass and some colouring agent, such as red lead, vermilion, Prussian blue, lampblack, or aniline colours. They are then dried in warm rooms, and finally packed in boxes. During the mixing, explosions are likely to happen and do serious damage, and also whilst packing or manipulating the finished matches.

The mixing, the spreading the composition on to a warm surface for the purpose of dipping, the dipping operations themselves, and the drying of the matches, are all dangerous from the escape of phosphorous vapour, which is inhaled, and leads to phosphorism.

Safety matches, in which the elements of combustion are in the tip, and the excitant on the rubber, are made in a different way. The pieces of wood are dipped into a mixture consisting of some igniting material, such as chlorate of potash and picric acid, and some fixing material, such as glue or starch. During the mixing of these, explosions are very likely to occur.

The phosphorus employed is of the red or amorphous variety, and this is not put into the match head, but on the rough rubbing surface.

The dangers, then, that are likely to arise in this manufacture are—(1) the inhalation of fine wood dust; (2) explosions; (3) those arising from the inhalation of phosphorus or from its local action on the skin: this is the most important danger of all,—in 1898 there were 21 cases of phosphorism, 20 of which occurred in match makers; and (4) lead poisoning.

1. Inhalation of wood dust. The bundles of cut pieces are covered with fine wood dust, and this, when scattered around during the manipulations of the wooden splints, is inhaled, giving rise to irritation of the organs of respiration. This could easily be avoided by having the bundles exposed to a good draught to blow the dust away, before they are used. Not much harm is caused in this way (see article on "Wood Manufactures," p. 33).

2. Explosions. These may occur during the mixing of the igniting materials, as has been mentioned in connection both with ordinary wood and safety matches, and also whilst removing the ordinary matches from the frames and packing them. The grinding of the various materials should be conducted separately, and they should then be mixed with glue. As they are mixed moist in this way, the danger of explosion is reduced to a minimum. Closed vessels should be used, and the mixing conducted most guardedly. The utmost care should be taken in any work requiring the manipulation of completed matches. Water should always be at hand to quench any fire.

3. A few words must be devoted here to the chemical properties of phosphorus. It exists in two important states —the yellow phosphorus and the red phosphorus. The yellow is a semi-translucent solid substance, very like wax. If exposed to the air, it oxidises, fumes being given off, which

are poisonous if inhaled. This spontaneous oxidisation is prevented by evaporating small quantities of oil of turpentine in the air. Phosphorus under these conditions does not glow or oxidise. It is very inflammable, the ignition taking place as the result of a slight blow, of friction, or even from the heat of the hand. It should always be cut under water, in which it is insoluble. It takes fire at a temperature of about 45° C.

Red phosphorus is a dark red opaque substance, the most important differences from the yellow being these, that it does not oxidise and give off fumes at the atmospheric temperature, and that its ignition point is very much higher than that of the yellow variety, being 260° C. It has no smell, and is not poisonous.

The fumes of phosphorus escape during almost the whole manufacture, but especially during the mixing, dipping, and drying. At any time when the phosphorus is exposed to the air, some of it is given off in the form of vapour, is breathed in by the workers, and gives rise to the symptoms known as phosphorism.

These symptoms are as follows:—There is loss of flesh and gradual change of colour of the skin to a yellowish hue. There is diminution of appetite, stomach and bowel trouble, headache, loss of brain power, and bronchitis. These symptoms do not usually show themselves before six months, often not for two or three years after engaging in the work. Then follows toothache, which seems to get perhaps a little better when the tooth is taken out. There are jaw pains, the gums swell and become tender and ulcerated, the breath becomes very offensive, the bone becomes diseased and dies, and finally the general health breaks down, and death may result.

It is a very important thing to remember that one of the chief channels of entry of the phosphorus into the system is by means of bad or decayed teeth.

The precautions to be adopted to guard against this danger are of very great importance, for if they are carefully carried out the risks of phosphorism are entirely abolished.

So far no substitute for phosphorus in match making has been discovered. There has been a good deal of controversy lately as to the advisability of entirely abolishing the use of yellow phosphorus in the manufacture of matches, but the opinion seems to be that for the production of matches which will strike anywhere (and this is the match most in demand) red phosphorus is unsuitable—yellow phosphorus must be employed. It must be remembered, however, that many experts contend that although the red phosphorus does not so readily ignite as the yellow variety, yet for all practical purposes it catches fire quite easily enough. It is to be hoped that this will turn out to be the case, for, by the substitution of the red for the yellow variety, industrial phosphorism would become a thing of the past.

Machinery has been invented, and is largely used, by means of which matches are made, dried, and boxed, without any close proximity of the workers. The reports so far received as to the working of the machine are excellent. Phosphorus poisoning seems almost to be abolished by the employment of this machinery. It is a great pity that the conservatism of British employers has prevented them from immediately adopting it. Many lives yearly would be saved, and much suffering and sickness prevented.

As to the future possibility of producing "strike anywhere" matches without yellow phosphorus, I think there is not much doubt that before long discoveries will be made which will make this practicable. Even now such matches are actually sold, but on account of their inferiority to the ordinary have not come into general use. So far, then, matches without phosphorus which will strike anywhere are

still on their trial. They are only in the experimental stage, but the prospects of their production in the near future, of such a quality as shall make them a commercial article, not merely a curiosity, is great.

The French Government have recently manufactured matches in which the sesqui-sulphide of phosphorus replaces the ordinary yellow phosphorus. They appear to be harmless, and do not cause phosphorus poisoning. So far they are still on their trial, but great things are hoped of them in the future.

Until the discovery of a suitable substitute for yellow phosphorus we must take every possible precaution against phosphorus poisoning.

All rooms should be large and lofty, and thoroughly ventilated (see Chap. VI.). The ventilation should be upward, as the vapour has a tendency to sink. There should be an apparatus to draw away the fumes and dust.

Great personal cleanliness is of the very utmost importance. The hands should be well washed with soap and scrubbing-brush and hot water before any food is taken. The mouth should be well rinsed also before eating or drinking, and the tooth-brush should be used to vigorously brush the teeth frequently. No meals should be taken in the workrooms. The clothes should be changed at the end of work, or else overalls worn, and hot baths frequently taken.

No man should be too long employed at any particular part of the work, but should change about from one kind to another.

The vapour of turpentine should be diffused in the workshop, and some may be carried on sponges attached to the workman's chest. If 4½ grains be evaporated for every cubic foot of space, this is sufficient to prevent oxidation and the giving off of fumes. If this cannot be borne,

vessels with a solution of sulphate of copper should be placed about the rooms: this leads to the precipitation of copper as phosphate of copper, and so prevents the fumes being harmful. Charcoal, too, is a good absorbent of the vapour, so some may be added to the solution.

The frequent use of a solution of carbonate of soda as a mouth-wash is good, and the teeth should be cleaned with the same, or else with lime water and charcoal. The greatest care and attention should be paid to the teeth. Any sign of decay, or of toothache, or of anything to raise a suspicion that the jaws are diseased in any way, must be promptly seen to. A medical man or dentist should at once be consulted.

The quantity of phosphorus in the various compositions differs considerably. The less there is, the less the risk of escape of vapour. Five per cent. is quite sufficient. There is no necessity to have more.

Any symptoms of the onset of phosphorus poisoning must be met by at once consulting a medical man.

4. Lead poisoning may arise from the use of red lead as a colouring matter for the matches: the way to avoid this would be to employ only aniline colours, which are just as serviceable (see "Lead Poisoning," p. 77).

Wool-sorter's Disease and Anthrax.

This is a disease communicated from animal to man by means of the carcass, hides, wool, or hair of infected animals. Those who are most liable to this terrible and fatal disease are the following: those tending or coming into contact with the infected live animals, such as herdsmen and shepherds; those who cut up the bodies of dead infected animals, such as butchers; those who come in contact with hides and skins, *e.g.* unloaders

of hides, wharf managers, stevedores, wharf labourers, sorters' labourers, merchants and buyers, carters, tanners, skinners, furriers, etc.; those engaged in the wool trade, *e.g.* wool sorters, washers, packers, carders, combers, overlookers, buyers, and staplers, and also flock makers, rag pickers, and horse-hair makers.

The animals most commonly infected with this disease are sheep, cows, horses, and puppies (not dogs), and the chief countries in which it exists are Russia, Turkey, Persia, France, and Germany; but it is by no means unknown in this country. Thus, in the years 1887 to 1895, the outbreak of anthrax in Great Britain numbered 2741, nearly 7000 animals being infected. In the year 1895 there were 434 outbreaks, 934 animals suffering. In 1898 there were recorded 28 cases in men in this country—16 in those engaged in the wool trade, 8 in those working in skins and hides, 3 in horsehair workers, and 1 in an odd trade.

The most dangerous of all the wools imported are those of Persia and Russian Tartary.

The disease may take two forms—the external, or malignant pustule; the internal, or wool-sorter's disease.

The infection may be by means of—(1) inoculation through a skin wound or abrasion, when the external form is caused; (2) inhalation of the infected particles of wool, hair, etc.; (3) swallowing of the same. In both of these the internal variety, or wool-sorter's disease, arises.

In the case of damp materials such as hides there is no dust to inhale, and the infection is simply through the skin, causing malignant pustule. In the case of dry and dusty materials (wool and hair) the infection may be by either of the three methods, and the disease may take either form, but more usually the internal variety is set up.

The symptoms of the external affection are as follows:—

The infected spot itches, and a small pimple rises—later this becomes a malignant pustule. This to an untrained observer is mistaken for an ordinary boil, but it should be recognised by certain characteristics. There is a great deal more swelling round it than there is round an ordinary boil; there are big and tender glands near; there is a black scab in the centre of the pustule, and round it a ring of small vesicles, which look like tiny blisters. The patient, at the same time, feels really ill, much more so than he would with ordinary boils.

In internal anthrax, or wool-sorter's disease, so called from the fact that a large number of those attacked follow this particular occupation, the worker may be perfectly well when he goes to business; he may in a short time become giddy, restless, and exhausted; he feels very ill, goes home, becomes feverish; his breathing is slow and shallow, his pulse feeble and rapid; there may be diarrhœa or vomiting; and, in bad cases, in from twenty-four hours to four days the patient dies unconscious.

In herdsmen and shepherds the disease is not common, especially in this country; but it is easy to see how one of them might be infected through a slight graze of the skin, from an infected sheep.

Those who are occupied in dealing with the dead carcases of animals may in the same way, but much more easily, be infected. Their hands are brought into intimate contact with the animal when engaged in cutting up, skinning, or slaughtering the animal; the fact, too, that a knife is used a good deal in these manipulations, and therefore that slight pricks and cuts may easily be caused and thus provide a ready channel of entrance for the poison, must be borne in mind.

Those who are occupied in dealing with the hides and skins are frequently infected—the tan yards of Bermondsey provide a good many cases. I saw a man not long ago who

had become infected whilst cutting up a piece of leather to make straps. The entry of the germs is by a skin abrasion.

Wool sorters, who mainly carry on their occupation in Bradford, provide most of the cases of internal anthrax. The workmen engaged in this work pull the fleeces apart and sort the wool into various heaps, according to its quality. This is a process which gives rise to a great deal of dust, which is scattered freely around, and breathed in by the workmen. The amount of dust, and therefore the likelihood of infection, will vary greatly with the kind of wool. If it is dry and dusty—for instance camel's hair and alpaca—a great deal of dust is created; if it is a greasy wool, such as sheep's wool, not so much is given off. The inhalation of particles of hair or wool from the bodies of animals dead of anthrax gives rise to the same disease in the individual breathing in the vitiated atmosphere.

Makers of Horse Hair.—Horse hair is a substance which is used for stuffing chairs and sofas, and for making cloth for covering chairs, etc. The hair imported from Siberia is the most dangerous. The process of manufacture is as follows:— The hair of the animal (manes and tails of horses, tails of cows, hair of pigs), which contains much dust, is sorted, washed, dried, and combed. The dust containing the infectious particles is inhaled, and anthrax results. The hair should all be boiled and dyed before it is sorted, and in this way the germs destroyed.

The following are the precautionary measures which have been advised by the Sanitary Committee of the Bradford Town Council, as necessary for the prevention of wool-sorter's disease. A series of regulations, of which the following is a modification, was originally suggested to the Council by Dr. Thomas Hime, then Medical Officer of Health for Bradford.

These regulations of Dr. Hime were better than the ones finally adopted, but had to be altered to meet the wishes of manufacturers.

1. All bales of wool or hair shall be opened by a person skilled in judging the condition of the material; any wool sorter to be deemed such person, if willing to perform the duty. If he find the contents unobjectionable, they shall be sorted in the ordinary way. If, on opening any bale, dead or fallen fleeces or damaged materials are found, such bale shall at once be taken from the room where opened, and dealt with as noxious. All Van, Persian, damaged wool, fallen fleeces, and foreign skin, wool, or hair shall be deemed noxious, and shall not be opened in the sorting room. Noxious wool or hair shall, before sorting, be thoroughly saturated with water, and then washed in hot suds, rolled, and sorted while damp, or if steeping would be injurious to the article, or would render difficult the working of the material, then it shall be disinfected.

Dr. Hime's suggestions on this first regulation were that any wool sorter was not a fit person—a fit person should be an experienced wool sorter, one who could recognise whether anything was wrong with the bale, and so prevent it being passed on to the sorters. He also thinks it would have been better to have left it optional as to whether any particular wool should be washed or disinfected, and not to have specified that some shall be washed and some disinfected.

2. No noxious material (alpaca, pelitan, or East Indian Cashmere) shall be opened in the sorting room, but in a place specially set apart for the purpose, separate and distinct from the sorting room, and all such material shall be opened over a fan by a person capable of judging the condition of the material.

3. The sorting rooms for all classes of mohair, camel hair, Persian, Cashmere, and alpaca shall be provided with extracting fans, so arranged that each sorting board shall be independently connected with the extracting shaft, in order that the dust arising from the material being sorted may be drawn *downwards*, and thus prevented from injuring the sorter.

Dr. Hime's comments on this regulation are as follows:— He thinks that it should apply to all dusty material, instead of those noted as being especially dusty; and also that there is no objection to the extraction being horizontal, if the conditions of the building are more suitable — what is required is to keep the dust from rising.

4. The dust collected by the fan must not be discharged into the open air, but be received into properly constructed catch-boxes. It must be afterwards burnt. This must be attended to at least twice a week. The sweepings from floors, walls, and from under the hurdles shall be similarly treated. All pieces of dead skin, scab, and clippings, or "shearlings," must be removed weekly from the sorting room, and must not be dealt with or sold until they have been disinfected.

The general rule that all dust must be burnt, is in Dr. Hime's opinion quite unnecessary. It might be rendered harmless and valuable.

5. All bags in which wool or hair has been imported shall be picked clean, and not brushed, and such bags shall not be sold or used for any other purpose until they have been disinfected.

6. No sorter having any exposed open cut or sore upon his person shall be allowed to sort.

7. A place shall be provided in which the sorters can leave their coats outside the sorting room, or in some suitable place covered over, during working hours.

Dr. Hime thinks the alternative of keeping the clothes "in some suitable place" is bad. It is a vague phrase, and may be variously interpreted. The place for keeping the coats, etc., should certainly be outside the sorting room.

8. Proper provision shall be made for the keeping of the sorters' food out of the sorting room, or in a closed closet therein, during working hours. No meals shall be taken in the sorting room.

As in regulation No. 7, there should be no alternative to keep the food in a cupboard in the room—it should never enter the room at all.

9. The sorting rooms shall be well ventilated by fans or otherwise; but as this cannot be effectually accomplished by open windows only, power shall be employed to secure *downward* ventilation, so arranged as to secure the workman from draught. The windows shall be kept open during meal hours. The sorting rooms shall be warmed during cold weather.

Dr. Hime, in his comments on the above, says it is very necessary that the rooms should be warmed, not only as a general hygienic measure, the rooms often being large and lofty, but also especially on account of the sorters, whose fingers get very numbed, so that they do not notice cracks

and scratches on their fingers, the existence of which is most dangerous.

10. No wool or hair shall be stored in the sorting room unless the same be effectually screened off from such room.

Dr. Hime regards the alternative provided as rendering the regulation almost useless. The prohibition was needed to prevent danger from infected wool stored in the rooms, often for months, to prevent sound wool thus stored from being infected by dust from other wool, and to prevent the cubic space required by the sorters being unduly curtailed and the free circulation of the air being impeded. No screening off of the room should be allowed.

11. The floor of the sorting room shall be thoroughly sprinkled with a disinfectant, so as to allay dust, and swept daily after work is over. The sorting room shall be thoroughly disinfected, and the walls thereof limewashed at least once a year.

12. Requisites for disinfecting and for treating scratches and slight wounds should be at hand in the sorting room, as thereby fatal consequences may be avoided.

13. Proper provision shall be made for the sorters to wash in or near to the sorting room.

14. A copy of these precautionary regulations shall be hung up in a conspicuous place in every sorting room.

These regulations, although by no means ideal, have been attended with the greatest benefit. If they could be modified in the direction suggested by Dr. Hime, still better results might reasonably be anticipated, and this horrible and fatal affection become more rare than it is at the present time.

Tin Plate Workers.

Although this is an occupation consisting mainly of metal work, it is not, like most of the other metallic occupations, followed by symptoms of metallic poisoning. The evil results of the occupation are chiefly due to the fumes of acid, etc., given off during the work, and to the high temperature at which the operations are carried on.

Tin plate making is thus conducted:—Very thin sheets of iron or steel are rolled out, after which they are doubled, and then cleaned by immersion in a solution of hydrochloric acid. The next process is to dip them in palm oil, and finally into melted tin, by which means a thin coating of this metal is deposited on the steel or iron.

The dangers run are due to the acid fumes. They cause irritation of the eyes, nose, and throat, decay of the teeth, and indigestion.

The constant immersion of the hands in the acid solutions also gives rise to cracks in them, which are, to say the least, very unpleasant.

Branning is the process by which the plates are completed; and here large quantities of dust are raised, and give rise to the usual symptoms caused by the constant inhalation of abnormal amounts of dust—to the article on which the reader is referred, at pp. 1 to 6.

As to the prevention of these dangers but little can be said. The workers must avoid, as far as is practicable, inhaling the fumes. All rooms in which the work is carried on must be thoroughly ventilated, and the hands should not be immersed in the acid solutions more than possible. If any injurious results do happen, a medical man must be consulted.

Oil Cloth, Floor Cloth, and Linoleum Manufacture.

Oil cloth is thus produced:—A sheet of canvas is stretched on a frame, and this is coated with size to smooth its surface. It is next painted thickly on both sides with a treacly paint, containing litharge or acetate of lead. This is several times repeated, and then the pattern is printed, and the fabric dried by artificial heat.

Linoleum.—Linseed oil (oxidised by exposure in a thin film to the air), rosin, and Kauri gum are all well mixed together, and made into a cement. This is heated in a steam-jacketed pot, provided with stirrers, an air-tight lid, and a pipe to conduct the vapour away. Very pungent vapours of acrolein are formed, and permeate the atmosphere. This cement is mixed with cork very finely powdered by machinery, and colouring matter added, yellow ochre and barytes for brown, and oxide of iron and vegetable black for red. It is rolled out in sheets, and applied to canvas made of jute, one surface being covered, the other varnished, or covered with size and pigment, and finally dried at a high temperature.

During the drying process irritating and pungent vapours of acrolein arise, and permeate the air.

The dangers belonging to this manufacture are as follows:—Explosions may arise during the powdering of the cork, or during the mixture of the cork and cement, or the cement may take fire spontaneously. Practically nothing can be done to prevent this.

The vapour of the unboiled linseed oil, which arises during the drying process, is very irritating to those breathing it. It should be burnt, by propelling by means of a fan to a furnace, and so prevented from reaching the atmosphere.

Lead poisoning from the paint used may arise. The

method of entry, the symptoms, and the means to be taken for its prevention, are all described at pp. 44 to 50.

Leather Making and Fellmongering.

There are a good many risks connected with this occupation, which may be divided into two main divisions: firstly, tanning, or the conversion of the raw hide into leather; secondly, currying, or rendering the leather soft, supple, and waterproof.

The fellmonger receives the hides and prepares them by removing the hairs. To do this, the skins are put into a wash of lime of no definite strength. This is used to dissolve the substances which unite the fibres of the skin together. The superficial part of the skin softens, swells, and loosens the hairs, which are now easily scraped away. It also renders the skin much more easy to clean. They are then soaked in water to remove the lime, and this operation is repeated several times. Orpiment, or sulphide of arsenic, is sometimes used mixed with the lime to facilitate the process.

In the tanning operations many substances are used: oak-bark, the extract of the rasped wood of the Spanish chestnut, an extract prepared from American hemlock pines, catechu, kino, sumach, etc. The ground-up tan is placed in cement-lined pits, and water poured in. The skins are first placed in a weak solution, then in a strong one, and so on. Finally they are taken out and dried.

In the currying process the skins are scraped and levelled to remove bits of flesh, etc., then heated and stretched, and finally oiled with some oil, such as linseed, castor, cod liver, or whale oil.

In the preparation of astrachan, an alkaline solution of oxide of lead is used. The skins when dried contain lead

dust, all ready to be scattered into the air and breathed in when the hides are moved.

The skins of foxes, badgers, rabbits, and otters are often treated with a mixture of oxide of lead, orpiment, acetate of copper, salt, and proto-sulphate of iron—a highly poisonous mixture.

The dangers which may arise in the course of this manufacture are—(1) anthrax; (2) lead poisoning; (3) arsenical poisoning; (4) poisoning by various gases.

Anthrax is fully treated of on p. 147. It is only when engaged in dealing with infected hides, of course, that those handling them are running any risk.

Lead poisoning arises from the entry into the body of the lead salts used in the various parts of the manufacture; they enter by the usual channels, and give rise to the ordinary symptoms. The preventative measures are those described under "Lead Poisoning." (See pp. 44 and 50.)

Arsenical poisoning: arsenic is used to preserve skins during carriage; it is used in unhairing, and is also contained in the mixture employed in treating badger and other skins. The mode of entrance into the system, the signs and the prevention, are described at p. 83.

The wash water from the skins treated with a mixture of lime and orpiment gives off sulphuretted hydrogen gas, leading to the production of arsenious acid and sulphurous acids. Some iron salts added to the wash prevent this, as an insoluble arseniate is formed.

Sore hands are caused by handling the orpiment and lime. It is doubtful whether gloves are advisable. They prevent the injurious material being removed at once if any should get under the gloves.

If gas lime is used instead of fresh lime, poisonous gases may be evolved in such quantities that fatal results follow.

Felt-hat Making.

There are many dangers incidental to this trade: there are the risks of arsenical or mercurial poisoning; there is the danger of inhaling abnormal quantities of dust; the risks from exposure to heat and steam; the danger of fissures and abrasions of the skin from frequent contact of the hands with hot acid water; wool-sorter's disease; and the inhalation of the fumes of methylated spirit.

The felt is made either from hair if a good quality is required, or from cotton if a common variety is needed.

In the manufacture of felt from cotton, this is carded, made into a sliver, and afterwards into a sort of thick, soft rope; then by machinery it is converted into a cone-shaped figure: the subsequent stages are the same as described below. But before being shaped the cotton felt is sheared smooth by machinery.

In making felt from hair, that of various animals, chiefly rabbits and hares, is used. The preparing of the hair is attended with the creation of much dust—dust of hair, of arsenic, and of nitrate of mercury, used for preserving the skins, and dust of any foreign matter that has accidentally got into the skins. The prepared hair is placed in boxes, attached to the circumference of a large wheel, which shakes it well and removes foreign particles. It is then placed in a long wooden box and driven by a current of air over and under a number of rotating wheels, by which process it is separated into the well-formed hair, fit for the manufacture of felt, and fluffy hair (a waste product only). The blower is the next machine. This drives it very quickly on to a metal cone, with many holes in it, upon which the hair gradually accumulates and forms a layer upon the cone. This is kneaded by hand into felt; it is now steeped in hot acidulated water, and passed between rollers

to press out the superfluous fluid; or this may be done by hand, the workers getting rid of the excess of water by rolling-pins. It is then dyed and shaped, the rough edge trimmed, and the whole rubbed over with sand paper. The lining completes the hat. Methylated spirit is used as a dressing, the vapour of which escapes, and is breathed in.

The risks of poisoning by mercury and arsenic are only run by those who prepare the hair—not the felt-hat makers, strictly: for a description of the modes of entry and preventative measure, see pp. 85 and 93.

The inhalation of excess of dust arises in many phases of the work—the dressing and cleaning of the hair, the sand-papering of the felt, and the shearing of the cotton felt. In getting the hair ready for the blower, and in the early stages of making felt, the machinery now employed is so well constructed that the scattering of dust is almost avoided.

The prevention of these evils may be avoided in the manner described at p. 3. Ventilation of the workrooms, the use of respirators, performing the dusty parts of the work (such as the shearing) under a tube with rotating fans, are the chief means to be employed.

Wool-sorter's disease may occasionally arise under the same conditions as those described at p. 147.

The whole of the felting process is carried out in the midst of heat and moisture. This is an enervating kind of work, and renders those engaged in it liable to catch cold very easily. As to prevention, no advice is possible.

The fissures of the hand due to the constant contact with acidulated water can be prevented only by keeping the hands out of the water as much as possible, and by having them medically attended to at the first appearance of the abrasions.

The inhalation of the vapour of methylated spirit is

productive of headache, nervous trouble, and inflamed eyes—it can unfortunately not be avoided where a dressing made of this substance is employed: any of the composition should be kept covered when not in use.

Glass Making.

This is a trade which has already been referred to under several heads, but which may be treated of in fuller detail here.

There are very many processes involved in this manufacture—the mixing of the ingredients to form the glass, the heating of the materials, the blowing, and the casting. As minor operations may be mentioned the smoothing, frosting, polishing, and engraving of glass.

In the actual making of the glass, sand, carbonate of lime, soda ash, lead, and arsenic are used, all in a powdered form. The mixing process entails the production of much dust, especially if done by hand, which may be inhaled by the workers. The founders heat the materials to make the glass, and are exposed to very high temperature from the furnaces, which are heated by coal or gas.

Blowers are the largest class of operatives. The pots of molten glass are kept heated on fierce furnaces, the atmosphere around being very hot and close. The workers must perform their blowing close to these furnaces, for they have to dip their blowpipes into the pots on the furnace, and to frequently approach the furnace in order to prevent the vessel they are blowing from cooling too much.

Glass Cutting.—In casting large sheets of plate glass, the melted glass is poured out and rolled into sheets, and here the workers are exposed to very great heat again.

The smoothing of such articles as the bottoms of tumblers has been already referred to—it is done by friction against a rotating wheel, with the help of water and sand.

Frosting is performed either by filing or else by a bar of glass with sand—plenty of water is used.

Plate glass is ground on a revolving table by means of sand and water, and polished, usually with putty powder, rouge, or some other powder, often without the aid of water. This has already been discussed in detail at p. 70, and nothing more need be said concerning it.

Cutting glass or engraving on it is performed by means of small rapidly rotating sharp-edged wheels, with rouge or putty powder. Brushes are also used; a great deal of dust is distributed in the atmosphere: the remarks on the dangers incidental to the use of putty powder made at p. 70 need not be here repeated.

The dangers belonging to this occupation, then, are: the inhalation of large amounts of dust, lead and arsenical poisoning, exposure to great heat, lung troubles of various kinds from the severe exertion of blowing, etc.

The dust is produced and causes its injurious consequences during the mixing of the ingredients, and during the smoothing, frosting, polishing, grinding, engraving, and cutting of the glass. All that has been said on pp. 1 to 6 applies here; the special point in prevention is to use wet instead of dry processes in these various manipulations, so that the dust is not so easily scattered. The mixing operations should be carried out by machinery instead of by hand. Gas is much better for heating the furnaces than coal, as it lessens considerably the amount of dust and smoke produced.

Arsenical and lead poisoning arise in the mixing of the ingredients, and lead poisoning also from the use of putty

powder. The reader is referred to pp. 72 and 85 on this matter.

Exposure to great heat is injurious, and leads to the liability of catching cold, rheumatism, prostration, or faintness. Care should be taken to avoid cold and draughts after exposure to a high temperature. Glass makers suffer in a large proportion from lung diseases of various kinds, bronchitis, asthma, etc. This is accounted for partly from the dust inhaled, partly from the severe exertion required in blowing, and partly from the readiness with which they catch cold. Machinery has been invented by Mr. Ashley which does away, in the manufacture of many articles, with the hurtful business of blowing.

Eye Accidents.

The importance of this subject can hardly be overestimated. Various workmen, especially grinders, miners, stonemasons, those occupied in iron and steel works, those engaged in cutlery manufacture—in fact all those employed in occupations where chips of metal or stone are caused to fly about at a high velocity—are very liable to accidents affecting the eye. These accidents so often leave defects of vision or even total blindness behind them—in fact a very large proportion of blind people owe the loss of their sight to an injury which might have easily been averted—that the subject is well worth careful consideration.

To show how common in certain trades these unfortunate mishaps are, it may be mentioned that, out of a total of 48,262 accidents of all kinds which came under the notice of the Miners' Provident Benefit Fund, no less than 2506, or nearly 5 per cent., were injuries of the eye.

A few instances to serve as examples may be dealt with a little fully, but what follows here is applicable to any of

the occupations referred to above. In edge tool, and other kinds of grinding, which is perhaps one of the trades in which these eye accidents are most liable to occur, the process is as follows:—The workman sits across a bench and presses his tool, say a knife or a razor blade, on his revolving stone. If dry grinding is employed, the minute particles of steel and stone fly freely around, and many of them must of necessity get into the eyes. Wet grinding certainly prevents the scattering about of the motes, but only to a certain extent, and not by any means entirely. In the case of emery wheels much the same thing occurs, and the dangers are exactly identical. Chippers, whose work consists in chipping the rough edge from castings of iron, steel, or brass, such as axle-box slides, chimneys, armour plates, etc., are again exposed to the impact of large showers of steel, iron, or brass particles, many of which reach the eyes. In the manufacture of millstones from French burr, a particularly hard substance, the stones have to be chiselled into wedges to form sections for the circular millstone. Specks both of stone from the French burr, and of steel from the tools, are scattered in all directions, to the detriment of the eye.

A different class of eye accidents is that due to the casting broadcast of molten metal. As the fused metal runs into the moulds, sparks and flashes fly about. In forging, too, the blows of the hammer cause minute pieces of red-hot metal to shower around; and it is surprising how frequently the eye is the part of the body the molten fragments seem to select.

The methods which may be adopted to prevent these accidents to the organ of vision are perhaps as important, if not more so, than in any other dangerous occupation, for the effects of eye injuries are so serious as regards sight that partial or total disablement from work is no uncommon final result. Firstly, we must try and prevent as far as possible

the chips and sparks from flying about; secondly, we must stop those that do fly about from reaching the eye. The measures to be adopted to attain the first of these results are as follows:—Whenever possible, revolving fans should be used in the workshops where grinding and such like operations are being carried out. It is really remarkable how the air current thus generated sucks in the flying "motes." The position of the workman should be so arranged that the small pieces of steel or stone should not be made to fly in the direction of another workman. Thus, in the case of chippers, for example, screens say of canvas, or some such material, should be interposed between sets of workmen, or they should chip against a wall. The introduction of pneumatic chippers would to a large extent prevent the dispersion of these tiny injurious fragments.

The second result is to be attained by the use of some form of eye protector. If the spectacles of a grinder who is suffering, say, from short-sightedness be examined after they have been in use some time, they will be found simply studded with small indentations where they have been struck by the flying solid particles—surely a convincing proof of the necessity of some form of eye protection. These "motes" would have probably all reached the eye had not the glasses been there to guard them. Eye protectors can be obtained at a low price, and made in such a way as not to affect the sight. Gauze wire made of galvanised iron or aluminium, with a fine mesh, and shaped so as to fit like a cup close to the eye, are very efficient, and interfere but little with sight. They should be worn by all those workers who are exposed to the little specks of iron or steel or molten metal. If the impact is not so violent as in the case of grinders, plain glass spectacles may be worn. These do not interfere with the vision at all, and are sufficient in this class of work.

As to what should be done when the injurious piece of metal has got into the eye, only one thing is to be said—it must be removed at once. In most works there is sure to be someone who has a reputation for skilfully extracting the motes, but, unless he is able to do so quickly, a competent surgeon should be at once consulted. An amateur operator must not be allowed to make repeated attempts at extracting the foreign body, lest serious injury result.

Artificial Respiration.

It is only necessary here to describe the method of performing artificial respiration for suffocation by poisonous gases, such as sulphuretted hydrogen gas, or to restore animation after apparent death from electrical shock.

There are several methods which may be employed: that most frequently used, and the one which is on the whole the most useful, is that known as Sylvester's method.

A pillow or a rolled coat is placed under the patient's shoulders, so that his head is low and his shoulders raised. Any clothes round the neck are loosened. The tongue must be pulled out, or else it is liable to fall back and prevent air getting into the chest. It must be kept in place by passing a piece of tape or an elastic band round the tongue and under the chin. One person should kneel behind the subject, and, grasping the arms just above the elbows, draw them with a sweep above the head; he brings them down again to the front side of the chest, and presses them very firmly inwards.

This should be done at the rate of fifteen times a minute —not more. There is a great tendency for the operator to do this more quickly. No brandy or other stimulants should be given, except under medical direction.

The above method is a very tiring one for one person to keep up alone. Unless he has someone to relieve him, he may be unable to manage it, and then Howard's method may be employed.

The patient should be placed face upwards, with a roll of clothing under the back just below the shoulder blades, to make the head hang back as low as possible. Place the patient's hands above his head. Kneel with the patient's hips between your knees, and fix your elbows firmly against your hips. Now, grasping the lower part of the patient's chest, squeeze his two sides together, pressing gradually forwards with all your weight for about three seconds, until your mouth is nearly over the mouth of the patient. Then, with a push, suddenly jerk yourself back. Rest about three seconds. Then begin again repeating these bellows-blowing movements with perfect regularity, so that foul air may be pressed out and pure air be drawn into the lungs, about eight or ten times a minute, for at least one hour, or till the patient breathes.

Another simple means of performing artificial respiration is to grasp the front half of the tongue with a handkerchief to prevent it slipping, and to pull this vigorously forward at the rate of about fifteen to eighteen times a minute. This stimulates the breathing apparatus, and sets up natural breathing, just as those ways described above do.

Besides performing artificial respiration, efforts should be made to rouse the patient by smelling-salts, burnt feathers, etc., held to the nostrils.

Even if there is no sign of the heart beating or of the recommencement of breathing, the efforts must be continued at least one hour. Success will sometimes reward these persevering efforts, even in cases apparently quite hopeless.

CHAPTER V.

TRADES IN WHICH VARIOUS POISONOUS VAPOURS ARE INHALED.

Indiarubber Works—Dry Cleaning—The Use of Spirit Paints.

THE MANUFACTURE OF INDIARUBBER AND GUTTAPERCHA GOODS.

DURING the process of manufacture of the various goods in which indiarubber is employed, such as, for instance, mackintoshes, rubber shoes, tennis balls, tobacco pouches, toys, and teats for feeding-bottles, various chemical substances are employed which give rise to the production of injurious fumes. The chief of these are naphtha and bisulphide of carbon, both of them compounds which readily volatilise.

The manufacture is conducted as follows:—The rough rubber is cleaned and dried and then dissolved in naphtha spirit, which is practically the universal solvent of indiarubber. The naphtha is poured on to the rubber, the colouring matter mixed with the mass, and the whole stirred about until it is made into a paste of a semi-fluid consistence called dough.

A few words as to the chemical properties of naphtha spirit must be made here. It is a colourless liquid, very volatile, the vapour readily diffusing; it has a low flash point, and very easily takes fire.

The operations of mixing are nearly always conducted at the bottom of the factory, and the result is that the vapour,

so readily given off, permeates not only these rooms, but also rises and goes through the whole building.

When cloth or other material is to be waterproofed, it is drawn between a roller and a long flat piece of metal, called a knife, so that a thin coating of the rubber paste is spread equally over its surface. The fabric is then dried over a heated table. The increase of temperature drives off even more vapour, and the worker is constantly breathing it.

After being spread, the material must be made up. Here the seams are carefully smeared with a mixture of rubber and naphtha, and then rolled and pressed. For this purpose small pots of naphtha and of solution (rubber and naphtha) are used constantly by the workers—and more naphtha vapour is added to the atmosphere, already overcharged with it. The pots are rarely covered, so that the evaporation is extremely free.

The constant inhalation of these fumes gives rise to faintness, loss of appetite, headache, a general feeling of weakness, giddiness, a feeling of sickness, and diarrhœa.

The preventative measures will be discussed after the injurious effects of carbon bisulphide have been treated of.

Carbon bisulphide is a colourless liquid, with a horrible odour, which readily volatilises, the vapour being heavy and therefore sinking downwards. It is highly poisonous. It is used for the purpose of vulcanising rubber goods—for instance in the manufacture of waterproofs, surgical rubbers, fancy articles, children's toys, or anything in which a great degree of elasticity is required.

The methods employed for vulcanising, or causing the penetration of sulphur, are various—the sulphur being communicated to the rubber in different ways. It is the carbon bisulphide method that it is necessary to discuss here. The machine is like that used for spreading, already mentioned—the roll of thick semi-fluid dough adheres to the surface, and

the fabric is passed through a trough of bisulphide of carbon. The horrible vapour is of necessity diffused throughout the workshop and inhaled.

The pieces are hung up by hand to dry; the men who perform this have to lie on their faces on the beams, and here they are especially exposed to fumes—the temperature at which the drying is conducted of course allowing more readily the production of the vapour.

The smaller articles are dipped by hand, after the required shape has been attained, into carbon bisulphide. The vapour freely escapes during these manipulations.

The symptoms of poisoning by carbon bisulphide are as follows:—The first stage is one of excitation, very like drunkenness—the man becomes active, talkative, irritable, sleepless, and violent; then he may pass into the second stage—that of depression, with loss of memory, loss of muscular power, blindness and headache. Temporary mania, leading to suicide, is not uncommon. A large proportion of the workers suffer from consumption, and, taking all the facts of the various illnesses to which they are subject, there is no doubt that the inhalation of these poisonous fumes is a very dangerous thing.

Mention must be made of the fact that, owing to the sticky nature of rubber, French chalk, or powdered chalk, is used to prevent the sheets, etc., adhering; a good deal of dust is scattered. There is also a certain method of vulcanising, in which sifted sulphur and colouring matter, such as lamp-black or oxide of zinc, are rolled in under great pressure, and in this process a good deal of dust is scattered and breathed in by the workers. The evil effects of this dust inhalation and its prevention is treated of at p. 1.

Sometimes litharge or oxide of lead is used as a colouring matter in the process of vulcanisation just referred to; and

the carbonate of lead enters into the composition of the varnish used to render certain articles impervious to wet, such as capes and aprons of coachmen. Lead poisoning may here arise: the channels of entry, symptoms, and means of prevention are fully treated of at p. 44.

The preventative measures to be adopted to diminish the evils due to the constant inhalation of the noxious and poisonous fumes and vapours of naphtha and bisulphide of carbon are detailed below.

The all-important question, since vapours and fumes of various kinds are at fault, is proper, efficient, and thorough ventilation. For various reasons the usual method of ventilating a room, namely by means of open windows, is not sufficient: firstly, it does not carry away the gases, so easily and constantly produced, sufficiently quickly; and secondly, the cold draught admitted dries the mixture of rubber and naphtha too quickly, and impedes the work.

In the spreading room cowls or hoods, with fans, are usually sufficient; in making-up rooms some special means of ventilation, such as an air propeller, must be used; and plenty of space, at least 500 cubic feet to each person, must be provided.

As the fluids evaporate so readily, any vessel which contains either naphtha or carbon bisulphide should have covers, which should be utilised whenever the vessels are not in use.

No one should work for too long together in a room in which carbon bisulphide vapour is diffused, and no young persons should be employed at this work.

Food should certainly not be kept or eaten in the workrooms, for it becomes saturated with the poison.

In vulcanising with carbon bisulphide the trough in which it is contained must be covered over and filled automatically: by this means a large amount of vapour is

prevented from escaping; the cloth, etc., should be conveyed to the drying room by machinery, just as is done in the case of wall-paper factories, and not moved by hand. No one should enter the drying room except for some special purpose.

In the vulcanising of small articles, usually carried out by hand, the goods should be dipped in enclosed cupboards, or at anyrate the fumes escaping from the vessels filled with carbon bisulphide should be drawn away from the workers by a suction apparatus.

In all parts of the factory where carbon bisulphide vapour is present, the machinery should be covered over and protected, and provided with a downward suction fan to draw the fumes away, as they are heavier than air.

In rooms in which ordinary waterproofing is done, the heated table used for drying should be fitted with a large hood to allow the vapours to escape—they may be conducted by pipes in connection with a fan to a condenser and used again.

If all these precautions are carried out, there is no doubt that a great deal of the disease caused in this manufacture would be avoided.

Dry Cleaning.

The cleaning of gloves, silk goods, and various other articles of clothing by the process of French or dry cleaning is thus conducted:—The garments, after the pockets have been examined for any inflammable substances (such as matches), are sorted, and then placed in a machine and covered with the cleaning spirit. The goods are thoroughly stirred about by the machinery to wash them well in the benzine. They are next placed in a centrifugal machine to remove the surplus spirit. The process of washing in benzine

and removing the surplus is again carried out, and the goods then removed and dried.

The cleansing of the different articles may vary slightly in detail from the above, but the main principle is the same in all.

The benzine which is used is either the spirit distilled from coal tar, or else manufactured mineral oil (spirit of petroleum). It is a colourless liquid, very volatile, the vapour rising readily, and resembling coal gas in odour; it is exceedingly inflammable, the flash point being very low.

It is plain how, with such a volatile substance, fumes must constantly fill the air of the workrooms.

The dangers incidental to this occupation are due directly to the vapour of the benzine employed: they are either those from the constant inhalation of the fumes, leading to poisoning; or those from the vapour igniting, and causing damage by fire.

The constant inhalation of the fumes of benzine gives rise to very much the same series of symptoms as those described under naphtha poisoning. They much resemble those of drunkenness. There is a stage of excitement, with headache, sickness, and loss of appetite, followed by a second stage of sleepiness, or even unconsciousness. The workers have a constant taste of the spirit in their mouths.

As the danger is due to the breathing in of the vapour, the chief method of prevention is to adopt an efficient system of ventilation, so that the fumes may be carried away instead of being inhaled.

Mechanical means, such as fans, must be used, and ventilators fixed in the rooms (see article on "Ventilation," Chap. VI.). At least 500 cubic feet of space should be provided for each worker.

It is important not only to carry away quickly the

vapour which has arisen, but also to use every expedient to prevent fumes from arising. To this end all the vessels containing the volatile spirit should be kept covered whenever practicable.

No food should be kept or eaten in the workrooms. It is rendered nauseous by becoming saturated with spirit.

The danger of fire from ignition of the inflammable vapours is great, and it is a very difficult risk to do away with. The precautions enumerated below will minimise them, but will unfortunately not prevent all fires.

All common-sense precautions will naturally be taken, such as keeping all naked lights away from the fumes, and so on.

The ignition of the vapour may be from causes more or less beyond control. Benzine is liable to spontaneous combustion, or an electric spark from friction of silk may set the fumes on fire.

The spontaneous combustion of benzine may be prevented by adding to it a little oil soap, which is thus made:—1 lb. of caustic potash or caustic soda is dissolved in 4 lbs. of alcohol. To each pint of the mixture add 1¾ pint of oleic acid, and heat the mixture. To keep the oleate of potash or soda in solution, add to every 100 parts of the mixture 250 parts of carbon tetrachloride, benzol, or other suitable solvent.

One-tenth to one-hundredth per cent. of this oil soap added to the benzine will prevent its spontaneous combustion.

The following are the recommendations against fire made by the Departmental Committee appointed by the Home Secretary to inquire into this subject:—

If a machine in which a fire takes place has a carefully constructed lid, very often the force of the expanded atmosphere

has pushed the lid up with sufficient violence to cause it to close down again immediately, by which means the fire is extinguished, without any of the goods in the machine being even singed. Evidence confirming this, as an actual experience, was given by several witnesses from different factories.

1. The Committee recommend that all machines, tanks, vessels for rinsing, or hydro-extractors, should be provided with a balanced lid or cover, which should be closed but not fastened down during the operation of cleaning or rinsing. They should be so constructed that upon the occurrence of an explosion or a fire they will, after being forced open, fall down again by their own weight. The Committee are aware that in the process of rinsing it is not often practicable to keep the vessel covered over. In such cases there should be attached to the ceiling, pillar, or beam above the rinser a cover or door of iron. This should be so constructed and adjusted that, in case of fire, by pulling a string or touching a catch it will instantly fall down upon the vessel, and cut off the supply of air from the burning spirit. In practice, advantage has been derived from having the string or catch at some distance from the extinguishing cover.

2. The soiled spirit from all washing and rinsing machines and hydro-extractors should, whenever practicable, be run off to the settlers or distilling apparatus in closed pipes.

3. Sand should be kept in abundance close to all places in which benzine or naphtha is used.

4. Blankets should also be kept in readiness in case of fire.

5. Men working in the processes in which spirit is used should wear woollen shirts and clothing.

6. All rooms above the ground floor in which any of the

processes of dry cleaning, involving the use of spirit, are carried on should be provided with an outside emergency staircase.

7. All dry-cleaning factories should be provided with hydrants, hoses, and an efficient water supply.

8. Wherever possible, incandescent electric light should be used. Each incandescent light should be enclosed not only in the small glass globe which usually surrounds it, but also in an outer air-tight envelope of glass. In cases where electric light cannot be procured, the rooms in which mineral spirit is used should be lit from the outside, the light being separated from such a room by a thick air-tight partition of glass.

The Use of Quick-drying Paints.

These paints are used when it is important, for the purpose of saving time, that some paint which will dry more quickly than the ordinary oil paint should be used. The most important and the most frequent example of its use is the painting of a ship in dock; it may be important to get her out quickly and to save the time necessary for the various coats of oil paint to dry: about two days can be saved by the employment of spirit paint.

These quick-drying, inflammable paints are made of the usual colouring matters, mixed with petroleum spirit, benzine, or methylated spirit, instead of oil. They are very volatile, and readily ignite.

The analysis of a sample of one of these paints gave the following results:—

35 per cent. volatile spirit.
38 per cent. resin.
26 per cent. mineral matter.

The volatile spirit flashed at 50° F., and was of a very objectionable odour.

The dangers occurring in the use of these paints are much the same as those which arise in other occupations where a highly inflammable and very volatile spirit is used—such as for example in dry cleaning, where benzine is employed, or in rubber works, where naphtha and carbon bisulphide are made use of.

They are directly attributable either to the inhalation of the poisonous vapour of the spirit, or to its ignition, and the consequent danger of fire.

The inhalation of the fumes gives rise to a kind of intoxication, with sickness and nausea, loss of appetite, debility, later on even to unconsciousness. If the worker should go on breathing the fumes whilst still unconscious, suffocation will result.

It is obvious, too, that the risk of fire is greatly increased by this danger of unconsciousness in the workman.

It is especially in confined spaces on board ship, such places as bunkers, tunnels, and ballast tanks, that the atmosphere is most likely to become saturated with the injurious vapours.

The risks of fire are always present when there is any of the inflammable vapour about. This is of course greater in the places mentioned, bunkers and tunnels, and so on; for the vapour is more concentrated, and the use of artificial lights is more necessary.

The means to be adopted to avoid both these dangers are the same. These paints should not be used in the confined spaces mentioned, and no naked lights should on any account be allowed to be brought near them. No man should work for any length of time in the day, say more than five hours, at this work.

If a worker is rendered unconscious, the immediate treatment is to get him out of the contaminated atmosphere into the fresh air, and to perform artificial respiration (see p. 166). A medical man should at the same time be sent for.

CHAPTER VI.

GENERAL HYGIENIC CONSIDERATIONS.

Preservation of Health — Sites for Factories—Warming of Factories—Lighting of Factories and Workshops—Ventilation—Water Closets.

A Few Simple Rules for the Preservation of Health.

Every workman should observe the ordinary simple rules of health, whatever his occupation. These rules are not difficult to attend to; they simply want a little care and trouble on the part of the individual, a certain amount of management, and they can easily be carried out.

First and foremost there is the necessity of taking outdoor exercise. This is vitally essential to everyone. Fresh air is the best medicine there is, and the workman should make it a rule to get some outdoor exercise every day—whether it be walking, cycling, football, swimming, or cricket. He should take any opportunity that presents itself, or, better still, he should *make* every opportunity of getting away into the country for a breath of pure air, even if it be only for the shortest of times. The change of scenery and surroundings, the different atmosphere, the forgetfulness of work, all do good and combine to keep him in health. At anyrate a determined effort must be made to get daily exercise of some sort in the fresh air, even if country jaunts are impossible.

The necessity for properly ventilating the home—the

bedroom, the sitting-room, and the kitchen—cannot be emphasised too greatly or repeated too frequently. The methods of ensuring a supply of fresh air to the rooms are fully dealt with under "Ventilation," at p. 186. This fresh air is the breath of life, and one cannot have too much of it. Bedroom windows should always be kept open, unless there is some special reason to the contrary, such as fog or the blowing in of wet or rain. It must be remembered, the cold only is no justification for closing the windows.

The diet taken should be of as good a quality as possible; fresh, not stale food, should be procured; and meals should be taken in as comfortable a fashion as is practicable. They must not be eaten in too great haste: the bolting of food is a common source of dyspepsia. Every mouthful should be well chewed, and an attempt should be made to arrange the heaviest meal of the day at such a time that a certain amount of leisure may be enjoyed after it.

The abuse of alcohol need not be discussed here. Every sensible man knows the terrible results of it. The illness, the deaths, the insanity, the crime, the misery, the disgrace, are too well known to need repetition, and no words can, unfortunately, influence those who are addicted to the habit. But perhaps young men, if they realised that there is hardly a single organ of the body—the liver, the kidneys, the brain, and the stomach, among others—which may not be afflicted with disease, leading to death, by the abuse of alcohol in any form, whether it be beer, wine, or spirits, might be tempted to inquire if, after all, the pleasure, or imaginary pleasure, of drink is worth the terrible price that has to be paid for it.

Tobacco in moderation does no harm, but the abuse of

this, as of anything else, leads to bad health—to indigestion, to blindness, to an irregular beating of the heart—and therefore it should not be indulged in, except in strict moderation.

Cleanliness, quite apart from such dangers and risks as are run by, say, lead workers or those using arsenic, from want of attention to it, is of the utmost importance.

The home should be kept well cleaned, not only for the comfort of it, but also for the healthiness of it.

Cold baths, taken daily, are undoubtedly a preventative of taking cold; and personal cleanliness of every description, of the hands, face, body, teeth, and so on, well repays the trouble taken to ensure it. These remarks will of course apply especially to those who are liable to get dirtied with poisonous materials, such as lead workers, and to those who get covered with dust of various kinds, such as sweeps and millers.

All these directions may be summed up in a single sentence: the workman should keep himself in the very best state of health possible, for by doing so he is very much less likely to be affected by the various risks and dangers of the trade which he follows.

As regards the prevention of dangers connected with occupations and trades, it is to be noted with regret that many of the plans and measures which have been devised at much trouble and expense by employers are very frequently, either from ignorance or from laziness, neglected by the workmen. Thus respirators, supplied for the purpose of preventing the breathing of dust, though supplied, are often not worn; the masks which ought to be put over the face when bottling aërated waters are omitted; and the spectacles to guard the eyes during grinding are put on one side.

Other measures entirely in the hands of the workman himself are in the same manner treated with neglect—the washing of hands after working with poisonous metals, the care which should be taken to avoid electrical shock, the attention which should be paid to the teeth by workers in phosphorus, are all forgotten. I am sure that once it has been brought home to the mind of the individual worker how much he may save himself in health and life, no trouble will be considered by him too great to be taken to avoid the dangers to which he is subject.

In the following remarks only a few brief hints are given as to the main essentials in lighting, ventilation, and so on. The details, of course, could only be properly dealt with by sanitary and practical engineers, but I have thought it worth while just to indicate to those in charge of factories a few points for consideration.

CHOICE OF A SITE FOR A FACTORY.

Unfortunately, the choice of a site for a factory so often depends upon other circumstances than hygienic conditions, that it is seldom that the ideal situation, determined by considerations of health alone, can be selected. However, just a few words may be said which will act as a guide in choosing the position of any new factory or workshop, when commercial interests will allow the health of the workpeople to be studied.

The soil should be a dry, porous soil, such as gravel, sand, or chalk: the dry soils are much healthier to live upon than the damp, wet soils. An elevated situation is superior to a low-lying one; and a position away from the heart of a great town, in an open space, where fresh air can play

around, must obviously present advantages over a crowded, impure spot, where no fresh air can get a chance of approaching.

Warming of Factories and Workshops.

The temperature at which factories and workshops should be kept is about 60° F. (15° C.). The production and distribution of heat for warming purposes may be carried out in the following ways:—

(*a*) By hot-water pipes heated by a furnace.
(*b*) By steam pipes heated by a furnace.
(*c*) By stoves (oil, coal, coke, gas).
(*d*) By open fires.

For factories and large rooms undoubtedly the best method of warming is either by hot-water pipes or steam pipes. Steam pipes are especially economical where steam power and waste steam are present. For small rooms, stoves or open fires may be used, if steam or hot-water pipes are not available; in fact, in many rooms open fires are to be preferred, for they act as efficient ventilators to the rooms by driving a current of hot air up the chimney, which must of necessity be replaced by fresh air.

Hot-water pipes are of two varieties—low-pressure and high-pressure.

The high-pressure pipes are constructed of very thick welded iron, the diameter of the bore being half an inch. There is no boiler, the tubes passing right through the fire. The water being under pressure can be heated to about 350° F. (180° C.).

The low-pressure system pipes are four-inch cast-iron

pipes. There is a boiler, in which the water is heated; it then passes through the pipes, during which it is cooled by parting with some of its heat to the air, and finally the circulation is completed by a return to the boiler, where it is again warmed. The water is not heated to boiling point, never reaching much more than 200° F. (93° C.).

Stoves.—In these coal, coke, gas, or oil may be burned. The air is warmed by coming in contact with the hot surfaces, and passes all over the room to warm it; here, as opposed to warming by means of open grates, the warmed air does not pass up the chimney, and thus a great waste of heat is avoided.

Stoves are either close or ventilated. There are a great many kinds of each. The ventilated stoves are much more healthy. They are so constructed that fresh air is drawn from outside the house or room, and made to pass through the stove, without coming in contact with the products of the combustion of the fuel. This warmed fresh air passes into the room.

Close stoves are not constructed in such a way as to provide any fresh air, and therefore it is plain how they are inferior to the ventilating stoves. The air is warmed and comes into contact with the products of combustion of the fuel, and thence passes about the room.

The disadvantages which apply to all stoves are two: firstly, they render the air very dry—this may be avoided partly by placing pots of water in any room in which a stove is employed for heating purposes; secondly, if the stoves become overheated a nasty disagreeable smell is produced, and this can only be avoided by taking care not to get the stoves too hot.

Open fires are very wasteful of heat, and by their use it

is impossible to equally heat a room all over—the nearer the fire, the warmer the part of the room.

They act as powerful ventilators of a room, by driving a current of hot air up the chimney, which must be replaced by fresh air.

A gas fire should always have a flue to carry off the noxious products of combustion.

LIGHTING OF FACTORIES—NATURAL AND ARTIFICIAL LIGHT.

All rooms and workshops should be well lighted naturally, by admitting as much daylight as possible; for not only is daylight of very great importance for the maintenance of health, but also to prevent eye strain, especially when many small articles have to be constantly manipulated in any way. Better work will be done in a better light—it will be easier to judge, for instance in dyeing, whether the right shade has been produced, or in grinding, whether the right edge has been attained, and so on. Therefore plenty of windows, properly arranged, is an economy.

As far as possible, light should penetrate the whole room, and it should be especially managed that for work on small articles it should come from the left-hand side, and not from the front.

Artificial light for the factory may be produced by gas, lamps, or electricity. Lamps are only mentioned to be unhesitatingly condemned. They are far too dangerous for use.

Coal gas is, up to the present, the illuminant which is most commonly employed. It is cheap, convenient, and efficient. The drawbacks are—(1) the danger of escapes, leading in large quantities to explosions, in small to the

contamination of the air; (2) the heating and drying of the atmosphere of the room—this can be partially obviated by placing vessels containing water about the room; (3) the substances produced by the burning of the gas (sulphurous and carbonic acid gases) are bad for respiration.

The electric light is every year becoming more common. It has many advantages over coal gas; it does not produce any irrespirable gases, it does not heat the air to any great extent, and it does not consume oxygen. It is more expensive than gas if supplied from cable mains, but, in factories where there is any large quantity of machinery at work, the dynamo to produce it could be run at an expense which would make it less than that of coal gas.

Electric lamps are of two kinds—the incandescent lamp and the arc lamp. If for small or moderate-sized rooms, the incandescent lamps are better, but for very large rooms or yards the arc lights are to be preferred.

Ventilation of Rooms, Mines, and Factories.

In almost every chapter and section of this work repeated reference has been made to the subject of ventilation, and its great importance as a preventative of disease in workers in almost every branch of trade (whether it be in the many occupations in which large quantities of dust are produced, such as cutlers, potters, or cotton makers, or in those trades where noxious fumes arise, such as in rubber works or chemical factories, or in mines and underground workings) has been insisted on over and over again.

Fresh air is a vital necessity, and it is essential that the used-up impure air of workrooms, dwelling-rooms, and factories should be frequently replaced by fresh pure air. According to the experiments of Aitken, the num-

ber of particles of dust in air from the open country is 2000 per cubic inch, in that from the air of cities 3,000,000, and in gas-heated rooms 30,000,000. The necessity for renewing gas-heated and other impure air is obvious.

The present chapter deals with some of the easiest and commonest methods of carrying out ventilation properly—methods which can be adopted by anyone: a reference in brief is also made to those means of removing the impure dust and poison laden air which is found in factories, by means of various mechanical devices. A full description of these various appliances of course cannot be given here,—a book on sanitary engineering must be consulted for that,—but sufficient can be said to indicate to those whose province and duty it is to provide adequate ventilation for workpeople the broad lines on which to work. As Parkes, one of the leading authorities on sanitary science, remarks, "Ventilation is a science, and it requires the study of a lifetime to master properly all its intricacies. The greatest engineering skill is necessary in the arrangement of tubes and the supply of fresh air."

The remarks made as to the necessity for fresh air apply equally to the dwelling-rooms, sitting-rooms, sleeping-rooms, and kitchens of workmen. It is just as important for them to breathe a pure atmosphere at home as at work.

First as to the bedroom. The popular prejudice against night air is unfounded. Cold air alone can do no harm to a healthy individual, and, so long as rain does not beat in and the atmosphere is not foggy, the top of every bedroom window should be kept open a few inches night and day all the year round.

The ordinary dwelling-rooms and kitchens can be best

ventilated as follows:—A block of wood is placed along the whole length of the lower sash frame of the window, and thus the top of the lower sash is raised above the bottom of the upper sash. The air current passes between the two sashes in an upward direction.

Fig. 1 represents a side view of a window so opened; Fig. 2, a front view. In Fig. 1, A is the top of the window, B the bottom, C the upper sash, D the lower sash,

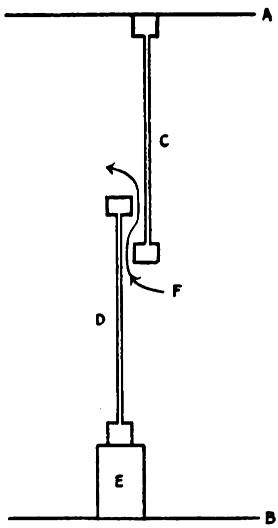

Fig. 1.

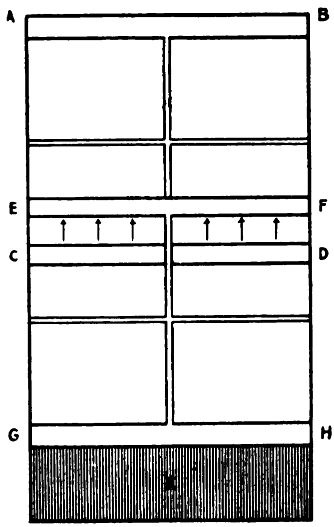

Fig. 2.

E the block of wood placed under the lower sash, and F the current of air, the direction being indicated by the arrows.

In Fig. 2, ABCD is the upper sash, EFGH the lower sash, and K the block of wood. The arrows indicate the direction of the air current.

There are many other simple and inexpensive means of attaining the same result, but none of them quite

so simple as the one described. Thus holes bored in the bottom rail of the upper sash in a perpendicular direction will allow a supply of fresh air to pass into the room, or a contrivance to allow one pane of glass to fall inwards, with side protectors to prevent draught, will answer the same purpose.

By adopting one of these simple contrivances no difficulty is experienced in providing a proper and sufficient supply of pure air to a room.

Mines.—All the underground passages, workings, and galleries of the mines are connected with two large shafts—an up and a down shaft. Fresh air is forced to pass down the down shaft; this passes through the galleries of the mine, displaces the air rendered impure and unfit to breathe by respiration, by the burning of lamps and candles, and by the explosion of dynamite, roburite, etc., and forces this impure air up the up shaft. Plenty of doors and partitions are necessary, otherwise the air would take short cuts and not ventilate many of the passages.

The force which supplies the pure air may be a very powerful rotating fan placed at the top of the up shaft. This draws up the air of the up shaft, and in consequence more air must pass in through the down shaft and through the galleries to supply its place.

Thus, in Fig. 3, A is the down shaft, B the up shaft, C the rotating fan, KK underground passages, the dotted line the air current, the direction being indicated by the arrows, down the down shaft, through the galleries, and up the up shaft.

The means for providing the current of air may also be supplied by a furnace at the bottom of the up shaft. This causes the air to ascend in the up shaft, and thus draws air

down the down shaft and through the workings, to supply the place of that removed.

In factories undoubtedly the best means of ventilation is to be found in shafts connected with revolving fans. These draw away not only impure air, but any solid particles suspended in the air, such as the dust of wool, stone, steel, lead, or whatever it may be. The speed at which they are run can be altered, and thus the draught regulated.

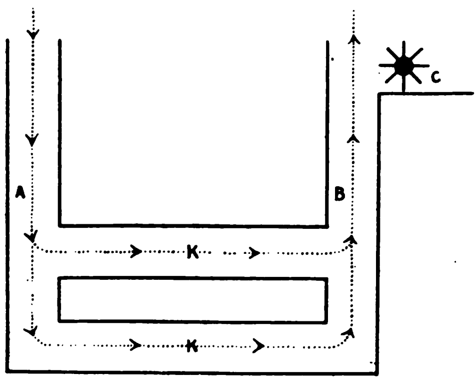

FIG. 3.

If all that is needed is to carry away used-up air and thus provide fresh air, one shaft in the centre of the room is generally sufficient — a powerful suction action is generated by the rotation of the fan and the air drawn away.

But if what is wanted is to take away dust, then, on the principle that it is better to prevent an evil than to remove it after it has happened, arrangements should be made to stop the escape of the dust into the general air of the room. The part of the room where the dust is created, say the bench of a wool-sorting room, or the wheel of a grinder, is connected

with the end of the extraction shaft or pipe, which is often here expanded into a hood or cowl, and at the other end of which the revolving fan is working: as the particles are formed they are drawn up into the hood by the suction action of the air current, and thus prevented from being thrown into the atmosphere. Experiments have been quoted already to show the enormous difference in the amount of dust deposited in a certain place in a certain time, when the fan was working and when it was not, all other conditions being the same, and thus the great utility of these fans demonstrated. (See p. 56, "Lead Poisoning," in the textile trades.)

The Blackman Air Propeller and the Sturtevant Blower are both good forms of fans; there are plenty of others—the particular form selected must be decided by the engineer, according to the particular room it is required to ventilate.

Water Closets.

To go fully into this subject would be beyond the scope of this work and occupy far too much space; but just a few words on this important matter will not be out of place.

Water closets are of many kinds — some good, some bad. The best are undoubtedly those constructed either on the hopper or the wash-out system. They are very much to be preferred to the old pan, valve, or plug closets.

What is known as the trough closet is the best for a factory, for it will do for many people at the same time, and is flushed automatically. It should be placed (the same applies to any closet) against the outside wall, and separated from the building by a passage or lobby; or,

better still, it may be quite disconnected from the building altogether.

Urinals are best constructed of china, stoneware, or slate, as they do not corrode like metals. They should have a sloping cemented floor, and be automatically flushed.

It is of the utmost importance that some competent sanitary authority should test and inspect the closets and drains from time to time—much ill health may be prevented by a timely remedying of any defects.

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